Public Comment
USFS Waiver
Deadline: 8/24/11 by 12:00 noon

SNOWLANDS Network

Promoting opportunities for quality, human-powered winter recreation and protecting winter wildlands

RECEIVED
8-16-11
SWRCB Clerk

State Water Resources Control Board
1001 I Street, 15th Floor
Sacramento, CA 95814

Emailed to: ForestPlan_Comments@waterboards.ca.gov

RE: Water Quality Management Plan for National Forest System Lands in California

August 16, 2011

Dear Sirs,

Snowlands Network and Winter Wildlands Alliance appreciate the opportunity to comment on the Water Quality Management Plan for National Forest System Lands in California. Snowlands Network is a California non-profit public benefit corporation with approximately 500 members that represents the interests of skiers, snowshoers, and other winter recreationists who desire to recreate in areas free from motorized use. Snowlands Network is a member of Winter Wildlands Alliance (WWA), a national advocacy organization representing the interests of human-powered winter recreationists and winter wildland conservationists. Collectively, WWA represents 30 grassroots member groups in 12 states with more than 30,000 individuals. Members of Snowlands Network and WWA regularly recreate on National Forest Lands in California and rely on these areas for clean and safe drinking water.

Of specific concern to Snowlands Network, WWA, and our members is the impact of unregulated snowmobile activity on water quality.

The State of California Department of Parks and Recreation, Off-Highway Motor Vehicle Recreation Division recently issued an Environmental Impact Report that considers the impact of an OSV Program funded by the Department.[1] Although the undersigned challenge the conclusions reached in that EIR, the EIR does provide useful information regarding the OSV Program and the extent of toxics emitted by snowmobiles.

[1] Over Snow Vehicle Program Draft Environmental Impact Report ("DEIR") Program Years 2010-2020, October 2010 (State Clearinghouse # 2009042113) confirmed by Over Snow Vehicle Program Final Environmental Impact Report Program Years 2010-2020, December 2010 (State Clearinghouse #2009042113)

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As disclosed in the EIR, almost all snowmobiles used in California[2] are two-stroke snowmobiles that discharge 25-30 percent of their fuel mixture unburned directly into the environment[3]. Snowmobiles using OSV Program facilities in California consumed approximately 1.25 million gallons of fuel in the 2010 season, and emitted in their exhaust over 1,000 tons of hydrocarbons, nearly 3,000 tons of carbon monoxide, 6 tons of nitrous oxide and 14 tons of particulate matter,[4] much of which is deposited on snow and enters the water table during snowmelt. Because the EIR considered only the impacts of the OSV Program, it did not include estimates of OSV usage and pollution at areas not served by the OSV Program. Accordingly, these figures understate the total pollution caused by OSVs in California and such understatement may be substantial.

The impacts to the water table from this discharge include increased toxicity and acid pulse that can further damage aquatic environments.[5]

Snowmobile usage on the national forests generally has not been managed by the United States Forest Service. The Forest Service has recently conducted broad-scale summer motorized travel management under Part B of the Travel Management Rule (36 CFR 212) but such planning has not encompassed snowmobiles, which are governed by Subpart C of the Travel Management Rule. Of greatest concern to the Water Resource Control Board should be the fact that this lack of management has continued in the draft Water Quality Management Handbook, which makes no reference to particular water quality issues related to snowmobiles.

Snowmobiles raise different issues than summer OHVs because:

- They generally cause more pollution per machine than other recreational vehicles because of their need for oversized power.[6]
- They emit their pollutants into the snowpack, which directly enters the water table at time of spring.

[2] DEIR §4.3.2.1 at p. 4-17.
[3] DEIR §4.3.3.2 at p. 4-31.
[4] DEIR Table 4-7, p. 4-19
[5]See "Impacts of Two-Stroke Engines on Aquatic Resources", Ruzycki, Jim and Lutch, Jeff, 1999. Included in Effects of Winter Recreation on Wildlife of the Greater Yellowstone Area: a Literature Review and Assessment ,Olliff, T., K. Legg, and B. Kaeding, editors., at pp145-149; "Winter Recreation Impacts To Wetlands: A Technical Review". Gage, Edward and Cooper, David J., 2009. (prepared for several national forests in Colorado); "Air quality at a snowmobile staging area and snow chemistry on and off trail in a Rocky Mountain subalpine forest, Snowy Range, Wyoming," Musselman, Robert C. and Korfmacher, John L. (February 2007).
[6] See "Environmental Impacts of Newly Regulated Nonroad Engines (Frequently Asked Questions)", United States Environmental Protection Agency, September 2002, p. 2

Because of these facts, the following changes are necessary to the Forest Service Water Quality Management Handbook and other related documents:

- Specific lands must be closed to older-technology 2-stroke snowmobiles when there is a significant likelihood such OSVs are contributing to degradation in water quality in lakes or streams.
- The Forest Service must be required to conduct monitoring and testing activity specifically related to the impact of OSV usage on water quality, either through modifications to BMP 4.7.5 or by the addition of a separate BMP specifically addressing OSV concerns.

In its EIR referenced above allowing the continuation of the OSV Program, the State of California, Department of Parks and Recreation, OHMVRD, apparently relied in part on an assumption that the Forest Service would be monitoring the water quality impacts of OSVs under its BMPs.[7]

Please revise and amend the BMPs in order to ensure this monitoring and testing will happen. Please require the Forest Service to immediately restrict usage of older 2-stroke snowmobiles in areas of particular concern to water quality.

We would be pleased to provide further information or to meet with the Control Board to discuss our concerns.

Sincerely,

Bob Rowen
Vice President – Advocacy
Snowlands Network

Forrest G McCarthy
Public Lands Director
Winter Wildlands Alliance
PO Box 6723
Jackson, WY 83025

Attachments:

EPA Frequently Asked Questions: Environmental Impacts of Newly Regulated Nonroad Engines September 2002

[7] DEIR §6.1.1.1, p.6-1

EPA Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines September 2002

DEIR, OSV Program

FEIR, OSV Program

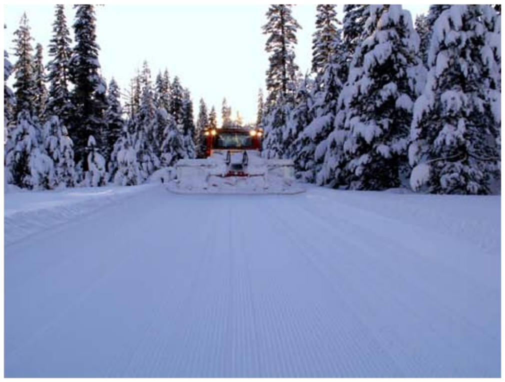
Effects of Winter Recreation on Wildlife of the Greater Yellowstone Area: a Literature Review and Assessment (1999)

Air quality at a snowmobile staging area and snow chemistry on and off trail in a Rocky Mountain subalpine forest, Snowy Range, Wyoming (2007)

Winter Recreation Impacts To Wetlands: A Technical Review (2009)

Over Snow Vehicle Program
Draft Environmental Impact Report
Program Years 2010 – 2020

State Clearinghouse # 2009042113



October 2010

State of California
Department of Parks and Recreation
Off-Highway Motor Vehicle Recreation (OHMVR) Division

Over Snow Vehicle Program
Draft Environmental Impact Report
Program Years 2010 – 2020

State Clearinghouse # 2009042113

October 2010

Prepared for:

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OSV PROGRAM DEIR, PROGRAM YEARS 2010-2020

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

Acronym/ Abbreviation/Symbol	Full Phrase or Description
AB32	California Global Warming Solutions Act of 2006
APCD	Air Pollution Control District
AQMD	Air Quality Management District
AQRV	air quality related value
ATV	all terrain vehicle
BAAQMD	Bay Area Air Quality Management District
BCP	budget change proposal
bhp-hr	brake horsepower-hour
BMP	best management practice
BSA	biological study area
CAA	Clean Air Act
CAAQS	California ambient air quality standards
Caltrans	California Department of Transportation
CAR	Critical Aquatic Refuge
CARB	California Air Resources Board
CDFG	California Department of Fish and Game
CDPR	California Department of Parks and Recreation
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
CH_4	methane
CHP	California Highway Patrol
CNDDB	California Natural Diversity Database
CNPPA	California Native Plant Protection Act
CNPS	California Native Plant Society
CO	carbon monoxide
CO_2	carbon dioxide
CRPR	California rare plant ranked
CSA	cost share agreement
CSSC	California species of special concern
CVC	California Vehicle Code
CWA	Clean Water Act
CWE	cumulative watershed effect
dB	decibel
dBA	A-weighted decibel
DEIR	draft environmental impact report
DMV	California Department of Motor Vehicles
DPM	diesel particulate matter
DTSC	Department of Toxic Substances Control
EIR	environmental impact report
EIS	environmental impact statement
EO	executive order
EPA	United States Environmental Protection Agency

Acronym/ Abbreviation/Symbol	Full Phrase or Description
ESA	Endangered Species Act
ESU	ecologically significant unit
FC	federal candidate (for listing under the federal ESA)
FE	federal endangered (under the federal ESA)
FPO	forest protection officer
FSS	Forest Service sensitive
FT	federal threatened (under the federal ESA)
g	gram
gal	gallon
GHG	greenhouse gas
HC	hydrocarbons
HFC	hydrofluorocarbon
hp	horsepower
HRCA	home range core area
IS	initial study
IS/ND	initial study/negative declaration
lb	pound
Ldn	day/night average noise level
Leq	equivalent noise level - the level of a steady noise having the same sound energy as the time-varying noise measured
Leq (h)	equivalent noise level - time-weighted average for a 60-minute (hourly) period
LEO	law enforcement officer
LEPs	law enforcement plans
LOP	limited operating period
LRMP	land resource management plan
MBTA	Migratory Bird Treaty Act
MMT	million metric tons
$MMTCO_2e$	million metric tons of carbon dioxide equivalent
$MTCO_2e$	metric tons of carbon dioxide equivalent
MVUM	motor vehicle use map
NAAQS	national ambient air quality standards
ND	negative declaration
NEPA	National Environmental Policy Act
NF	national forest
NMFS	National Marine Fisheries Service
NO	nitric oxide
NO_2	nitrogen dioxide
N_2O	nitrous oxide
NOP	Notice of Preparation
NOx	nitrogen oxides
NSR	new source review
NVUM	National Visitor Use Monitoring
NWPS	National Wilderness Preservation System
OHMVR Division	Off-Highway Motor Vehicle Recreation Division

Acronym/ Abbreviation/Symbol	Full Phrase or Description
OHV	off-highway vehicle
OSV	over snow vehicle
PAC	protected activity center
PFC	perfluorocarbon
$PM_{2.5}$	particulate matter less than or equal to 2.5 microns in diameter
PM_{10}	particulate matter less than or equal to 10 microns in diameter
PRC	Public Resources Code
PSD	prevention of significant deterioration
ROD	record of decision
ROG	reactive organic gases
ROS	recreation opportunity spectrum
RWQCB	Regional Water Quality Control Board
SC	state candidate (for listing under CESA)
SCAQMD	South Coast Air Quality Management District
SE	state endangered
SEIS	supplemental environmental impact statement
SF_6	sulfur hexafluoride
S&Gs	standards and guidelines
SFP	state fully protected
SJVAPCD	San Joaquin Valley Air Pollution Control District
SOPA	Schedule of Proposed Actions
SOx	sulfur oxides
SUV	sport utility vehicle
SWRCB	State Water Resources Control Board
TAC	toxic air contaminant
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
VMT	vehicle miles traveled
VOC	volatile organic compounds
WDR	waste discharge requirement
WHPP/HMP	wildlife habitat protection program/habitat management plan
WIN	water improvement needs

S.0 SUMMARY

S.1 PROJECT DESCRIPTION

The OHMVR Division proposes a 10-year funding commitment of the Over Snow Vehicle (OSV) Program for the operation, maintenance, and grooming of winter recreation trails and trailheads in mountainous regions throughout California. The OSV Program comprises 26 trail systems in 11 national forests. The project locations extend from the Oregon border south towards Bakersfield and range in elevations from 4,000 to 9,900 feet. In total, the Project involves plowing 97 miles of access roads, plowing parking areas and/or maintaining restroom service at 34 trailheads, and grooming 1,761 miles of trail. These project activities (snow removal, trail grooming, and facility maintenance) facilitate the primary purpose of winter recreation use of national forest trails for motorized (over snow vehicles) and also support and benefit non-motorized users, such as; cross-country skiing and snowshoeing by providing motorized access for those activities. All of the groomed trail systems in the Project Area were established over a 10-year period from 1982 to 1992 with the exception of one which was added to the OSV Program in 1996. These activities associated with the OSV Program have been occurring annually at each trail site since its inception.

OSV Program trails are used each year by an estimated 159,000 OSVs bringing upwards of 200,000 visitors to the Project Area. Growth in OSV ownership has occurred at an average annual rate of 4% since 1997. Assuming the same growth rate, project trails may have an annual OSV usage of 235,000 and 300,000 visitors by 2020. To accommodate the increased demand for motorized winter trails, the OHMVR Division anticipates expanding the groomed trail system to include new groomed trail locations, expanded trailhead parking areas, and increased frequency of grooming operations on existing trail systems. Presently, OSV Program equipment operations involve 2,076 snow removal (plowing and/or blowing) hours and 4,948 grooming hours throughout the Project Area. Projected growth by 2020 would increase equipment operations by 700 plowing hours and 1,100 grooming hours.

S.2 IMPACTS AND MITIGATION

The impact analysis presented in this OSV Program Draft Environmental Impact Report (DEIR) considers whether continuance of state funding for trail grooming, plowing, and maintenance service and the subsequent recreational use it facilitates will cause significant effects as defined by the California Environmental Quality Act (CEQA). A summary of project impacts and mitigation measures is provided in Table S-1. A complete discussion of project impacts and mitigation measures is provided in the DEIR sections pertaining to each environmental discipline (see Chapter 3.0 through 8.0).

Table S-1. Summary of Project Impacts and Mitigation Measures

LAND USE PLANS AND POLICIES	
IMPACT: If inventories and subsequent monitoring show that OSV use is damaging CNPS or FSS populations, the OSV Program would conflict with forest-wide LRMP biodiversity S&Gs in several national forests which require maintenance of viable populations of native plant species or sensitive plant species (Appendix D, Table 1). **Potentially Significant Impact**	**Measure BIO-4:** (see Biology below or Section 5.4 of the DEIR for a complete description) **Less than Significant Impact After Mitigation.**
IMPACT: OSV trespass into wilderness areas facilitated by project groomed trails could occur under baseline use levels and would likely increase beyond present levels due to growth in OSV recreation over the 10-year program period. Current areas of trespass which may receive a higher incidence of intrusion include: Mount Shasta Wilderness (Klamath National Forest), Lassen Volcanic National Park and Caribou Wilderness (Lassen National Forest), Bucks Lake Wilderness (Plumas National Forest), Mokelumne Wilderness along Squaw Ridge (Eldorado National Forest), Kaiser and John Muir Wilderness (Sierra National Forest), Carson-Iceberg Wilderness (Stanislaus National Forest), Mokelumne Wilderness between Hope Valley and Lake Alpine (Eldorado and Stanislaus National Forests), Golden Trout Wilderness (Sequoia National Forest), and South Sierra Wilderness (Sequoia National Forest). **Potentially Significant Impact**	**Measure LU-1:** All national forests participating in the OSV Program shall monitor wilderness boundaries, private property, and other closed areas near the groomed trail system for OSV incursions. National forests shall submit patrol logs to Division showing hours and days of patrol in known trespass locations, number of observed trespass incidents, and number of citations issued. National forests shall identify to the OHMVR Division what management actions have been taken and what, if any, additional actions are needed to further prevent trespass into wilderness areas, private property, or other closed areas. OHMVR Division shall work with law enforcement personnel from the USFS and County Sheriff Offices to implement focused enforcement actions as needed to address trespass incidents such as increased patrol frequency, aerial patrols, public education, signage, fencing, or trail closure. **Less than Significant Impact After Mitigation.**
AIR QUALITY, ENERGY AND GREENHOUSE GASES (GHG)	
IMPACT: Direct project emissions from snow grooming and snow plowing equipment and indirect emissions from vehicle travel to Project Area and OSV use of project trails under baseline (Year 2010) and program growth (Year 2020) conditions would contribute PM_{10}, ROG, and NOx (ozone pre-cursors) to local air basins which are in non-attainment for PM_{10} and ozone state standards. Emissions would occur during winter months when background levels of PM_{10}, ROG, and NOx are low and the emissions are mobile and widely dispersed. Ambient air quality standards would not be violated. **Less than Significant Impact**	**No mitigation required.**
IMPACT: Direct project fuel use is 59,000 gallons per year rising to 74,000 gallons per year by 2020 with projected program growth levels. Indirect fuel consumption from OSV use and vehicle travel to project trail sites combined	**No mitigation required.**

Table S-1. Summary of Project Impacts and Mitigation Measures	
is 2.9 million gallons per year rising to 3.4 million gallons per year by 2020 with projected program growth levels. Given the increased demand for OSV recreation in conjunction with the increased energy efficiency of the motorized equipment, the level of fuel consumption does not cause inefficient, wasteful, or unnecessary use of energy resources. **Less than Significant Impact**	
IMPACT: Total project direct and indirect GHG baseline (Year 2010) emissions are estimated at 27,118 MTCO2e. These are existing emissions that already occur and represent no new emissions to the statewide GHG emission inventory. **Less than Significant Impact**	**No mitigation required.**
IMPACT: Program growth by Year 2020 would increase in GHG emissions to 32,069 MTCO2e which is an increase of 4,951 MTCO2e above baseline conditions. No standards for GHG emissions apply to statewide mobile emissions, particularly from off-highway recreation vehicles. Therefore the Project does not conflict with applicable plans. The increase in GHG emissions is less than several significance thresholds used by several air quality management districts governing stationary sources and land use developments. **Less than Significant Impact**	**No mitigation required.**
BIOLOGICAL RESOURCES	
IMPACT: Northern spotted owls and northern goshawks occur within or near the Project Area. USFS actively monitors nesting habits and fledgling success. Management actions are currently in place that reduce the potential effects of OSV recreation on northern goshawks and northern spotted owls to a less than significant level. The USFS employs adaptive management. Thus, based upon the results of the Regional Northern Goshawk Focused Study and the Northern Spotted Owl Focused Study, biologists may revise the USFS Management Actions. **Less than Significant Impact**	**Measure BIO-1:** USFS shall incorporate the results of the northern goshawk and northern spotted owl studies into management actions and report these actions to the OHMVR Division for incorporation into the OSV Program as soon as revised USFS management actions are formulated. **Less than Significant Impact After Mitigation.**
IMPACT: California wolverine is not known to be present near OSV sites. If present, disturbance caused by OSV activities may adversely affect California wolverine natal denning behaviors. **Potentially Significant Impact**	**Measure BIO-2:** USFS shall continue to work with the Pacific Southwest Research Station and other partners to monitor for presence of California wolverine. If there are verified wolverine sightings, USFS shall conduct an analysis to determine if OSV use within 5 miles of the detection have a potential to affect wolverine and, if necessary, a LOP from January 1 to June 30 will be

Table S-1. Summary of Project Impacts and Mitigation Measures

	implemented to avoid adverse impacts to potential breeding. **Less than Significant Impact After Mitigation.**
IMPACT: Disturbance caused by OSV activities may adversely affect Sierra Nevada red fox breeding behaviors, home range use, and/or establish trailhead scavenging and begging behaviors. **Potentially Significant Impact**	**Measure BIO-3:** Educational materials shall be provided on red fox and the importance of minimizing direct contact with red foxes at each trailhead. USFS shall provide the results of Sierra Nevada red fox inventory and monitoring currently being performed by wildlife biologists from the Forest Service, CDFG, and the University of California, Davis, to the OHMVR Division. USFS shall work with CDFG, the University of California, Davis, OHMVR, and other partners to continue inventory and monitoring in the Sierra Nevada, including the Project Area where the red fox is most likely to occur (e.g., Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Sierra, Inyo, and Sequoia National Forests). For those portions of the Project Area where presence is confirmed, USFS shall conduct an analysis to determine if OSV use within 5 miles of the detection have a potential to affect Sierra Nevada red fox and, if necessary, a LOP from January 1 to June 30 will be implemented to avoid adverse impacts to potential breeding. The USFS will evaluate activities for a 2-year period for detections not associated with a den site. In addition, if monitoring or other scientific information shows disturbance of Sierra Nevada red fox behaviors within the Project Area, the USFS shall implement suitable management actions to reduce any adverse impacts to a less than significant level. These management actions may include signage, barriers, LOPs, limits on night riding, trail closures, or reroutes of selected portions of OSV trails. **Less than Significant Impact After Mitigation.**
IMPACT: OSV off-trail riding in low snow conditions could adversely impact individuals and/or populations of CRPR-listed 1B and 2 plant species and FSS plant species. **Potentially Significant Impact**	**Measure BIO-4:** The USFS will do one of the following: (1) Only permit OSV use on the groomed trail system and adjacent concentrated-use riding areas when there is sufficient snow cover (minimum snow depth of 12 inches) to protect soil and vegetation; (2) Inventory the groomed trail system and adjacent concentrated-use riding areas for all CRPR 1B, CRPR 2, and FSS plant species not already monitored by USFS (Table 5-6) for OSV impacts. Surveys shall focus on locations that are chronically exposed to OSV use and where plants listed in Table 5-6 have a potential for occurrence and exposure to OSV impacts. The USFS shall conduct public outreach with educational materials until resource surveys are complete. Educational materials shall include information that discourages OSV travel over bare ground, exposed vegetation,

Table S-1. Summary of Project Impacts and Mitigation Measures	
	and snow less than 12 inches deep, including a description of the special-status plant species potentially affected and the adverse effects on those species. The species previously assessed and not included in this Mitigation Measure include Kern Plateau milk-vetch, Hall's daisy, Kern River daisy, and Kern Plateau horkelia, Mono milk-vetch, Mono Lake lupine, slender Orcutt grass, Barron's buckwheat, and Columbia yellow cress. Follow-up monitoring shall be conducted for those species where presence is confirmed to ensure any protective measures needed to address OSV impacts are identified, implemented, and effective. Protective measures that shall be implemented when needed to avoid damage to special-status plants from OSVs include trail reroutes, barriers, seasonal closures, signage, and/or public education; or (3) Annually monitor the groomed trail system and adjacent concentrated-use riding areas where plants listed in Table 5-6 have a potential for occurrence. Monitoring shall focus on locations that are chronically exposed to OSV use and where plants listed in Table 5-6 have a potential for occurrence and exposure to OSV impacts. If this monitoring reveals impacts, USFS shall implement protective measures (e.g., temporary fencing, barriers, seasonal closures, signage, trail re-routes, public education, etc.) to restrict access and prevent further damage to these plants and engage in public education. Follow-up monitoring shall be conducted to ensure that protective measures are implemented and effective. **Less than Significant Impact After Mitigation.**
IMPACT: Chronic disturbance caused by OSVs riding during low-snow conditions over wetlands, riparian areas, streams, and lake ice can adversely affect aquatic communities. **Potentially Significant Impact**	**Measure BIO-5:** USFS shall annually monitor aquatic resources in the Project Area near the groomed trail system for damage by OSV use during low-snow conditions. If these assessments reveal impacts, USFS shall implement protective measures (e.g., fencing, signage, trail reroutes, etc.) to restrict access and prevent further resource damage and engage in public education. **Less than Significant Impact After Mitigation.**
HYDROLOGY/WATER QUALITY	
IMPACT: Exhaust emissions on snowpack from grooming equipment and OSV can enter surface water. Level of VOC entering water system determined to be within acceptable range and do not cause exceedance of water quality standards. **Less than Significant Impact**	**No mitigation required.**
IMPACT: OSV use in low snow conditions or on bare soil could cause soil compaction and erosion.	**No mitigation required.**

Table S-1. Summary of Project Impacts and Mitigation Measures

Less than Significant Impact	
NOISE	
IMPACT: Equipment noise from snow grooming and plowing and noise from OSV recreation use would occur. Noise from plowing would occur on roads consistent with vehicle noise. Trail grooming noise occurs in late night hours when outdoor recreation is generally not occurring. OSV engine noise is audible to other motorized and non-motorized recreationists using the national forest. Noise levels fall within acceptable range for outdoor recreation. **Less than Significant Impact**	**No mitigation required.**
RECREATION	
IMPACT: Potential growth in OSV use levels projected over the 10-year program period may result in increased conflicts between motorized and non-motorized user groups. Such growth could also lead to a need for additional USFS law enforcement or forest protection officer staffing to ensure adequate public safety services. **Potentially Significant Impact**	**Measure REC-1:** USFS shall continue to monitor trailheads and groomed trail areas for potential conflicts between motorized and non-motorized users in the Project Area. USFS shall ensure patrols occur with the necessary frequency needed to maintain adequate police and forest protection services. If monitoring results show conflicts between motorized and non-motorized uses cause chronic public safety risks, or that existing staffing levels are inadequate to maintain necessary public safety services, the USFS and OHMVR Division shall implement necessary site-specific controls to reduce safety risks such as trail use restrictions, speed limits, segregated trail access points for motorized and non-motorized users, public outreach providing maps and other information about alternative sites for non-motorized recreationists within the Project Area, or increased staffing. **Less than Significant Impact After Mitigation.**
IMPACT: Parking demand at trailheads serving the groomed trail system exceeds parking capacity at several locations. Currently, the excess parking demand is adequately controlled by national forest staff and California Highway Patrol so that illegal or unsafe parking conditions are minimized. Increased trailhead visitor levels over the 10-year program period without corresponding increases in parking capacities could increase the potential for unsafe parking conditions. **Potentially Significant Impact**	**Measure REC-2:** Each national forest shall document to the OHMVR Division the opportunity and constraints for addressing unsafe parking conditions at trailheads where unsafe parking conditions are documented or anticipated due to growth. Measures to address such conditions may include signage, education, directing recreationists to under-utilized sites, and increased patrols with citations as appropriate. Where trailhead road widths permit, national forests shall establish designated unloading and loading zones and vehicle turnaround areas. National forests may consider increasing parking capacity through increased road shoulder plowing provided by OSV Program funding or coordination with Caltrans or county road departments where road widths can accommodate the parking. **Less than Significant Impact After Mitigation.**

Source: TRA Environmental Sciences, Inc. 2010.

S.3 PROJECT ALTERNATIVES

S.3.1 Alternatives Considered and Rejected

The range of project alternatives considered in this section is limited due to the site-specific nature of the project facilities and the project objective of continuing maintenance of the existing trail systems in the national forests in support of the OSV Program winter recreation. Several potential project alternatives were considered and rejected due to infeasibility and/or not reducing or avoiding the environmental effects of the project. The rejected alternatives include: Alternative Project Locations, Closure of Trail Systems, Closure of Off-Trail Riding Areas, Prohibition of Two-Stroke Engines, Shortened 10-Year Funding Period, and Funding of OSV Program through Grants Program.

S.3.2 No Project Alternative

Under the No Project Alternative, the Division would not fund the OSV Program. Funds to the 11 national forests and 3 county transportation/road departments would not be issued. Trail grooming would not occur on 1,761 miles of trail at the 26 trail system locations. Plowing at 27 of the 34 trailheads would be discontinued. The seven OSV Program trailheads which share parking with sno-parks in Eldorado, Stanislaus, and Sierra National Forests would continue under separate funding by the state Sno-Park Program. The trailhead plowing which occurs at Inyo National Forest is not funded by the OSV Program and would also continue to be provided by the City of Mammoth Lakes. Thus, under the No Project Alternative plowed access would no longer be available for 1,342 miles of ungroomed trail but would provide access to 419 miles of ungroomed trail. Restroom facilities at trailheads maintained by OSV Program funds would not be serviced.

Without snow removal, trailheads may be inaccessible for parking due to presence of snow. Parking along the side of the access roads and highways may occur and could present a traffic safety hazard. Public use of the ungroomed trail routes would likely be substantially reduced but not eliminated. Exhaust emissions in the air and on the snow pack and noise levels would be reduced due to elimination of project grooming and plowing equipment and fewer OSV users visiting the Project Area. The potential for significant impacts to biological resources from OSV use would be reduced. Incidents of OSV intrusion into closed areas would likely be reduced but not eliminated. Ungroomed trails could slow an emergency response for search and rescue creating a public safety impact. Restroom service and garbage collection at many of the trailheads would be discontinued. This could result in trash and sanitation issues at the trailheads or along the trail routes.

S.3.3 Funding Restricted Riding Areas Only

Under the Funding Restricted Riding Areas Only Alternative, the OHMVR Division would only fund trail grooming in areas where OSV use is restricted to designated routes by the land managers; no grooming would occur where off-trail riding is permissible. At least initially, this alternative would eliminate grooming at 24 of the 26 trail systems. Grooming would continue on two trails systems in the Giant Sequoia National Monument (Big Meadow/Quail Flat and Quaking Aspen/Sugarloaf) where off-trail riding is prohibited. Grooming could be expanded to other locations where the land manager has enacted riding restrictions. With only the trails in the Giant Sequoia National Monument groomed, this alternative would reduce the trail mileage groomed under the OSV Program from 1,761 to 130 miles. The OSV Program would also only fund access road and trailhead plowing and services at those areas with trail grooming. Direct access to trailheads plowed by Caltrans at the seven shared trailhead/sno-parks would continue unaffected.

Similar to the No Project Alternative, visitor use of the trail systems no longer groomed via the OSV Program would likely be substantially reduced. As a result, exhaust emissions in the air and on the snow pack and noise levels would be reduced due to elimination of project grooming and plowing equipment and fewer OSV users visiting the Project Area. The potential for significant impacts to biological resources from OSV use would be reduced. Incidents of OSV intrusion into closed areas from the ungroomed trail locations would likely be reduced but not eliminated from reduced OSV use. Without groomed trails to demarcate authorized routes, inadvertent trespass could increase if national forests decrease law enforcement patrols on ungroomed trails. Ungroomed trails could slow an emergency response for search and rescue creating a public safety impact. Redirection of OSV riders to the two trail systems in the Giant Sequoia National Monument could dramatically increase OSV use in the monument and create a need for increased law enforcement patrols and public outreach to enforce trail riding restrictions, address use conflicts, and provide adequate officer presence to maintain public safety.

S.3.4 Redirection of Grooming Funds

Under this project alternative, grooming frequency throughout the Project Area would be reduced to free up funding for law enforcement and resource monitoring. Plowing would remain unchanged in order to preserve access to all trailheads. Under the Redirection of Grooming Funds alternative, OSV use throughout the Project Area would still continue but likely be reduced. Based on the Winter Trailhead Survey (Appendix A), half of the respondents indicated that they were less likely to visit the trailhead if the trail system was not groomed. This alternative would not necessarily stop grooming but would substantially reduce the frequency of grooming, leaving trail conditions rough and potentially increasing safety hazards by the uneven snow surface. A reduction in grooming could also result in a proper trail width not being maintained. A narrowed trail width going around curves with two-way vehicle direction could increase the accident risk. Exhaust emissions in the air and on the snow pack as well as noise levels in the Project Area would be reduced due to reduced grooming equipment operation and fewer OSV users visiting the Project Area. The potential for impacts to biological resources from OSV use would be reduced to the degree that OSV use is reduced. Incidents of OSV intrusion into closed areas may be somewhat reduced by fewer numbers of riders on the trails; however, given that trespass occurs in ungroomed locations the number of intrusion incidents would likely remain the same as the Project. Reduced visitor use of the trail systems would reduce parking demand at project trailheads, relieving crowded conditions on peak use days.

S.3.5 Environmentally Superior Alternative

The No Project Alternative is the environmentally superior alternative; however, it does not meet the project objectives. Two project alternatives can partially meet the objectives, which include Funding Restricted Riding Areas Only and Redirection of Grooming Funds. Of these alternatives, the Funding Restricted Riding Areas Only is the environmentally superior alternative.

S.4 AREAS OF CONTROVERSY/ISSUES TO BE RESOLVED

CEQA Guidelines Section 15123(b) requires the EIR Summary to identify areas of controversy known to the Lead Agency including issues raised by agencies and the public and issues to be resolved including choice among alternatives and whether and how to mitigate the significant effects.

Issues of public concern raised by the public were identified through public comment on previous Initial Studies and comment raised during public scoping meetings held on the EIR (see Introduction, Section 1.5). The primary issue of concern raised in public comment is the environmental effects of snowmobile use in general.

1.0 INTRODUCTION

1.1 BACKGROUND

National forests throughout California offer winter recreation trails and parks to the public for snowmobiling, cross-country skiing, snowshoeing, and snow play. Plowing of local access roads and trailhead parking lots, grooming trails for snowmobile use, and light maintenance of facilities (e.g., restroom cleaning, garbage collection) are the essential elements of the OSV Program that keep the national forests open for winter recreation use. Winter recreation in national forests has been occurring for many years with annual motorized recreation steadily increasing.

Many national forests and local agencies receive funds from the California Off-Highway Vehicle (OHV) Trust Fund for management and maintenance of OHV use in the non-winter months as well as over snow vehicle (OSV) use in the winter months. Until 2005, the OSV funds were awarded via competitive grants issued under the competitive Grants and Cooperative Agreements Program, which is administered by the California Department of Parks and Recreation (CDPR), Off-Highway Motor Vehicle Recreation (OHMVR) Division. The OHMVR Division now administers OSV Program funds for plowing, grooming, and trailhead facility maintenance activities through cost sharing agreements (CSA), which are direct contracts independent of the competitive Grants and Cooperative Agreements Program (Grants Program). Periodic funding for additional support services for winter recreation such as supplemental staffing and equipment purchases may still occur through the Grants Program.

In 2008 and again in 2009, the OHMVR Division evaluated its one-year OSV Program funding as a project under the California Environmental Quality Act (CEQA). In both years, an Initial Study (IS) was prepared resulting in adoption of a Negative Declaration (ND). The IS/ND environmental analyses concluded that OHMVR Division funding of the OSV Program would facilitate the use of an existing winter trail recreational system; the funding contracts would not expand the trail system or change the current environmental impacts of the system. Given that the contracts would not alter baseline conditions, the environmental analyses concluded that the contracts would not result in new environmental impacts. Given that the U.S. Forest Service (USFS) had resources in place to address potential impacts of the existing winter trail use (law enforcement, resource monitoring, and adaptive management), the analyses also concluded that the contracts would not facilitate the continuance of any adverse impacts from the existing use.

In 2009, the OHMVR Division proposed to modify its OSV Program from an annual consideration to a 10-year funding commitment. The OHMVR Division decided to prepare an Environmental Impact Report (EIR) for CEQA compliance and issued a Notice of Preparation (NOP) for the EIR in April 2009 and held public scoping meetings as discussed in Section 1.5 below. The purpose of this EIR is to evaluate the potential environmental effects of the OHMVR Division entering into CSAs to fund the OSV Program activities conducted by national forests and county agencies. The contracts would fund the OSV Program for 10 years covering the winter seasons from 2010/2011 through 2019/2020.

1.2 INTENDED USE OF EIR

The OHMVR Division is the Lead Agency for this project under CEQA (Public Resources Code § 21000 et seq.). CEQA and the CEQA Guidelines (14 CCR §15000 et seq.) establish the OHMVR Division as the Lead Agency, which is defined in CEQA Guidelines Section 15367 as "the public agency which has the principal responsibility for carrying out or approving a project." In this case, the OHMVR Division is allocating funds which allow the OSV Program to operate. The Lead Agency decides whether an EIR or ND is required for the project and is responsible for preparing the appropriate environmental review document.

This EIR has been prepared by the OHMVR Division of CDPR in accordance with CEQA and the CEQA Guidelines. This EIR will be used for the purpose of evaluating the environmental effects associated with issuance of state-funded contracts for the activities described in the Project Description. Other sources of funding supporting winter trail recreation such as funding by national forests is not addressed.

It is the intent that this EIR address the direct and indirect activities associated with state maintenance of established OSV Program trail systems over the 10-year program period. It is foreseeable that maintenance levels funded by the OSV Program can change over the years. It is the intent of this document to provide CEQA review that can accommodate adjustments and fluctuations in maintenance operations. It is not the intent of this document to provide CEQA review for development of new trail systems or infrastructure. However, the potential for new groomed trails to open during the next 10 years is addressed and should these identified trails undergo CEQA review and become established, it is the intent of this EIR to provide the environmental review necessary to extend the OSV Program maintenance activities described in the Project Description (Chapter 2.0) to that established trail system.

1.3 PERMIT REQUIREMENTS

No permits from the OHMVR Division or regulatory agencies are required for project activities.

1.4 LEAD AGENCY CONTACT INFORMATION

The Lead Agency for the proposed project is the OHMVR Division, the agency that would be funding the project. The contact person for the Lead Agency is:

> Ms. Connie Latham – Associate Park and Recreation Specialist
> California Department of Parks & Recreation
> Off-Highway Motor Vehicle Recreation Division
> 1725 23rd Street, Suite 200
> Sacramento, CA 95816
> (916) 324-3358

1.5 ISSUES OF PUBLIC CONCERN

In April 2009, the OHMVR Division prepared a NOP (Appendix H) for the OSV Snow Program Challenge CSAs. Additionally, the OHMVR Division held three public scoping meetings in May 2009 to invite comment on the scope and content of the environmental review. These meetings were held in Redding, South Lake Tahoe, and Fresno. One written response to the NOP was received and is attached in Appendix G. The respondent expressed support for the OSV Program citing economic, safety, and recreation benefits.

The OHMVR Division previously prepared an IS/ND in 2008 and 2009, each for a single year operation of the Snow Program. One comment letter was received on the 2008 IS/ND. The same comment was resubmitted on the 2009 IS/ND. The primary issues of public concern raised in the comment letter include:

- Grooming and snowmobile technology allows more use, farther and faster travel, and deeper incursions into remote areas, including trespass into wilderness areas.
- Increased funding for monitoring and law enforcement.
- Potential effects of snowmobile use on plants and wildlife.
- Potential effects of snowmobile use on people (noise, air quality, and water quality).

These issues are addressed in the following chapters of this DEIR: Land Use Plans and Policies (Chapter 3.0), Air Quality, Energy, and Greenhouse Gases (Chapter 4.0), Biological Resources (Chapter 5.0), Hydrology and Water Quality (Chapter 6.0), Noise (Chapter 7.0), and Recreation (Chapter 8.0).

2.0 PROJECT DESCRIPTION

2.1 OVERVIEW

The OHMVR Division OSV Program proposes to provide funding to national forests and local public works agencies to support winter trail recreation throughout California for a ten-year period from 2010/2011 to 2019/2020. As of 2010, the OSV Program comprises 26 groomed trail systems on 11 national forests. Operation and facility maintenance activities include plowing 97 miles of access road, plowing parking areas and/or maintaining restroom facilities at 34 trailheads, and grooming 1,761 miles of snowmobile trails. Additionally, the OSV Program funds administrative actions such as purchase and maintenance of equipment, preparation and printing of trail maps, and end of season trail monitoring. The groomed trails are predominately maintained for OSV (snowmobile or snow machines) use; however, other OHV users also use the trails in limited areas, Nordic skiers, snowshoers, and other non-motorized recreationists can also use the parking areas and groomed trail systems. This EIR considers the environmental effects of the OHMVR Division entering into contracts to fund the OSV Program under the existing program level condition as well as under a program growth condition which could occur over the 10-year program period covering the 2010/2011 through 2019/2020 winter seasons.

Through the CSAs, both the State and USFS share in the cost of implementing the OSV Program. While the State's OHV Trust Fund is used for the plowing and grooming activities, the USFS provides paid staff for law enforcement, public education, and resource protection. Depending on the terms of each CSA, either the State or USFS fund garbage collection at trailheads, restroom maintenance, and signage. For purposes of this EIR, the State-funded grooming, plowing, facility maintenance, and administrative purchases and support activities are considered direct actions (described in Section 2.4 below), while the USFS funded tasks are considered related actions (described in Section 2.5 below). Both the proposed project and related actions support the indirect action of winter trail recreation such as snowmobiling, skiing, snowshoeing, and snow play. Both the direct and indirect actions are considered in the environmental analysis.

2.2 PROJECT OBJECTIVE

Pursuant to the California Vehicle Code, the OHMVR Division is required to manage OHV use which includes OSVs. As expressed in the California Public Resources Code, the Legislative Intent is for the OHMVR Program to manage OHV use "in a manner that will sustain long-term use." The OHMVR Division disperses a portion of OHV Trust Funds to agencies responsible for managing and maintaining the facilities supporting OSV use. To this degree, in issuing OSV Program contracts, it is the objective of OHMVR Division to facilitate and manage OSV recreation throughout California by providing plowed access roads and trailhead parking, groomed trails, and facility maintenance such as restroom and garbage services and trail signage.

2.3 EXISTING SITE DESCRIPTIONS AND LOCATIONS

The OSV Program funded activities (the Project) occur in national forests located throughout the mountainous regions of California (Figure 1, Regional Location). The project locations extend from the Oregon border (Klamath and Modoc National Forests) south towards Bakersfield

(Sequoia National Forest). The roads and trails are generally located between elevations 4,100 and 10,000 feet. Trails in a few locations fall above and below these elevations. For the next 10 years (winter seasons 2010/11 through 2019/2020), the OHMVR Division proposes OSV Program funding in 11 national forests and county roads which access the forest trailheads. Agency funding is further described in Section 2.9. A list of project locations is presented in Table 2-1 at the end of this section. A brief description of each national forest project site and its recreational use is presented below. Collectively, these trail sites and adjoining riding areas comprise the Project Area.

2.3.1 Klamath National Forest – Goosenest Ranger District

Deer Mountain and Four Corners Medicine Lake Snowmobile Parks. The Deer Mountain and Four Corners trails and trailheads can be accessed via Highway 97 north of Weed (Figure 2A, Deer Mountain and Figure 2B, Four Corners Medicine Lake). These trails and trailheads are a part of the tri-forest grooming plan, which includes Klamath, Modoc, and Shasta-Trinity National Forests. The tri-forest grooming plan has a total of 273 miles that is groomed according to snow conditions and priority. In this plan, 135 miles of roads and trails are groomed in the Deer Mountain Snowmobile Park and Four Corners Medicine Lake Snowmobile Park areas by the Goosenest Ranger District of the Klamath National Forest and Mt. Shasta and McCloud Ranger Districts of Shasta-Trinity National Forest. The tri-forest trail system provides 250,000 acres for snowmobiling and links four trailheads that can be traveled in one day – Deer Mountain, Four Corners Medicine Lake, Doorknob, and Pilgrim Creek. Trail elevations range from 5,400 feet to 7,400 feet. The Deer Mountain and Four Corners Medicine Lake trailheads have warming huts, vault restrooms, and parking for public use. Other winter recreational activities that occur in Klamath National Forest include cross country skiing, dog sledding, and snow play. Roughly 28 miles of road accessing Four Corners Medicine Lake trailhead are plowed each winter by a private contractor to Klamath National Forest – 17 miles on Red Rock Road (county road) and 11 miles on Forest Route 15 (USFS road). Four miles are plowed on Deer Mountain Road (Forest Route 19) to access Deer Mountain.

2.3.2 Modoc National Forest – Doublehead Ranger District

Doorknob Snowmobile Park. Modoc National Forest is within a four-hour drive of Reno and Redding and a one hour drive of Klamath Falls, Oregon, Merrill, Oregon, and Tulelake, California. It has one snowmobile park, Doorknob trailhead, that is located on Forest Route 49 1.5 miles south of Lava Beds National Monument headquarters (Figure 3, Doorknob). The trailhead features a paved parking lot, warming hut, and restrooms, from which users access the Medicine Lake trail system. This 10-year-old trail system has 52 miles of marked, groomed gravel road and 15 miles of unmarked trail. Trail elevations range from 5,500 feet to 7,100 feet. It connects to the tri-forest trail system that includes three trailheads and approximately 221 additional miles of snowmobile trails that are groomed and maintained in Klamath National Forest (Deer Mountain and Four Corners Medicine Lake) and Shasta-Trinity National Forest (Pilgrim Creek). Modoc National Forest receives a considerable amount of overflow use from these two other interfacing trail systems. It does not have a snowcat, and all of its trail grooming is conducted by Klamath National Forest. Four miles on Forest Route 49 are plowed to provide access and parking at the Doorknob Snowmobile Park trailhead. Plowing service is contracted out by Modoc National Forest to Lava Beds National Monument (National Park Service) using OSV Program funds.

2.3.3 Shasta-Trinity National Forest – Mt. Shasta and McCloud Ranger Districts

Pilgrim Creek Snowmobile Park. The Pilgrim Creek trailhead, also part of the tri-forest trail system, is located off of State Route 89, 33 miles east of McCloud (Figure 4, Pilgrim Creek). The trailhead can be accessed by following Pilgrim Creek Road for five miles north to the junction of Forest Routes 13 and 19. Trail elevations range from 4,100 feet to 6,600 feet. Mt. Shasta and McCloud Ranger Districts of Shasta-Trinity National Forest and Goosenest Ranger District of Klamath National Forest groom the 86 miles of trails of the Pilgrim Creek trail system. Mt. Shasta and McCloud Ranger Districts plow the Pilgrim Creek trailhead and eight miles of access road (Forest Route 13) and maintain a warming hut and service a restroom. Other winter recreational activities that occur in Shasta-Trinity National Forest include cross-country skiing, dog sledding, and snow play.

2.3.4 Lassen National Forest – Hat Creek, Eagle Lake, and Almanor Ranger Districts

Ashpan Snowmobile Area. The Ashpan Snowmobile Area, which has been in operation for 26 years, is on State Route 44/89 four miles northeast of the north entrance to Lassen Volcanic National Park (Figure 5A, Ashpan). Ashpan offers 35 miles of groomed trails and access to another 30 miles of groomed trails associated with neighboring Latour State Forest. The Latour State Forest trails are not groomed by OSV Program funds. This trail system travels through mixed conifer forests with the higher sections containing views of Mount Lassen, Mount Shasta, and the upper Sacramento Valley. Trail elevations range from 5,400 feet to 6,000 feet. The Ashpan trailhead has a parking lot, warming hut, and restroom. The Hat Creek Ranger District is responsible for the operation and maintenance of the Ashpan Snowmobile Area. Plowed trailhead access is provided by Caltrans but could be provided by a private vendor under contract to Lassen National Forest in the future.

Bogard Snowmobile Area. The Bogard Snowmobile Area is located 25 miles northwest of Susanville on State Route 44 (Figure 5B, Bogard). Trailhead parking and restrooms are provided off State Route 44 at Forest Route 10. Bogard offers 80 miles of groomed trail ranging in elevation from 5,600 feet to 7,700 feet. To the east of the highway are ungroomed meadows and two groomed trails: Antelope Mountain Lookout and Crater Lake. Antelope Mountain Lookout has 16 miles of trail with panoramic views of Mount Lassen, Mount Shasta, and the Warner Mountains. Crater Lake has seven miles of trail. The meadows of Pine Creek Valley are the focal point of snowmobile use in Bogard. There are also 30 miles of ungroomed forest roads that travel through the Pine Creek Valley to Eagle Lake. To the west of the highway are trails that travel through pine and fir forests and connect to Hat Creek rim to the north and Swain Mountain to the south. The Eagle Lake Ranger District is responsible for the operation and maintenance of the Bogard Snowmobile Area. Plowed trailhead access is provided by Caltrans but could be provided by a private vendor under contract to Lassen National Forest in the future.

Swain Mountain Snowmobile Area. The Swain Mountain Snowmobile Area is located north of Lake Almanor off Mooney Road (County Road A-21). The area can also be accessed from the Chester-Lake Almanor staging area at Lake Almanor on Forest Route 10 off State Route 36 (Figure 5C, Swain Mountain). Each trailhead provides parking and restrooms. Swain Mountain has 60 miles of groomed trails and three loop trails and is the hub of Lassen National Forest's snowmobile system. Trail elevations range from 5,200 feet to 6,800 feet. It provides direct access to Fredonyer and Bogard Snowmobile Areas and 200 miles of marked trails (groomed and ungroomed). The Almanor Ranger District is responsible for the operation and maintenance of the Swain Mountain Snowmobile Area. The Swain Mountain trailhead and Chester-Lake Almanor trailhead along with 0.25 miles of Forest Route 10 are plowed by the Plumas County Road Department.

Fredonyer Snowmobile Area. The Fredonyer Snowmobile Area is located on State Route 36, 10 miles west of Susanville (Figure 5D, Fredonyer). The area has 80 miles of groomed trails, a parking area, a warming hut, and a restroom. The Fredonyer Snowmobile Area can be accessed from three different areas. The primary access is from the Fredonyer trailhead on State Route 36 at Fredonyer Pass. Additional pullout parking is available along the road shoulder dependent upon plowed conditions. Willard Hill, a few miles further east on State Route 36 also provides access with pullout parking along the road. South of Susanville, Gold Run Road (County Road 204) provides an ungroomed trail link to the Fredonyer trails. The Fredonyer trails are located on both the north and south sides of State Route 36 with the northern trail route linking to the Swain Mountain Snowmobile Area. Trails on the south side of State Route 36 offer various loop trails which traverse through a combination of forest and open meadow and offer views of the Great Basin and the high country around Mount Lassen. Trail elevations range from 4,800 feet to 7,000 feet. The Eagle Lake Ranger District is responsible for the operation and maintenance of the Fredonyer Snowmobile Area. Plowed trailhead access is provided by Caltrans but could be provided by a private vendor under contract to Lassen National Forest in the future.

Morgan Summit Snowmobile Area. The Morgan Summit Snowmobile Area is located four miles east of Mineral on State Route 36 and State Route 89 (Figure 5E, Morgan Summit). This snowmobile area has 77 miles of groomed trails, a parking lot, restrooms, and a warming hut maintained by the Almanor Ranger District. It contains loop trails and the trail to Turner Mountain Lookout that has views of the central Sacramento Valley, Sutter Buttes, Lake Almanor, and Mount Shasta. Trail elevations range from 4,800 feet to 6,900 feet. The Morgan Summit trail system is groomed by both volunteers and USFS groomer operators. Plowed trailhead access is provided by Caltrans but could be provided by a private vendor under contract to Lassen National Forest in the future.

Jonesville Snowmobile Area. The Jonesville Snowmobile Area is located in the Lake Almanor area between State Routes 32 and 89. The Jonesville trailhead is located on Humboldt Road off State Route 32 about two miles east of the Cherry Hill Campground and provides a parking lot and restrooms. The Jonesville trails can also be accessed from the Almanor Picnic Area on State Route 89 on the west shore of Lake Almanor (Figure 5F, Jonesville). Jonesville offers 70 miles of groomed trails and three loop routes that follow Humbug and Humboldt county roads. Trail elevations range from 4,600 feet to 6,600 feet. Views of the Lake Almanor Basin can be seen from the Yellow Creek loop. Colby Mountain Lookout is a popular destination in the Jonesville area. Trail grooming is provided by Butte Meadows Hillsliders Snowmobile Club under contract to Butte County. Seven miles of Humboldt Road from State Route 32 to the trailhead is plowed by the Butte County Road Department.

2.3.5 Plumas National Forest – Mt. Hough, Feather River, and Beckwourth Ranger Districts

Bucks Lake Trail System. The Bucks Lake trail system is located west of Quincy on Bucks Lake Road (Figure 6 A, Bucks Lake). The trail system offers 100 miles of groomed trails ranging in elevations from 4,000 feet to 5,900 feet. The trails are accessed from two staging areas, Bucks Summit and Big Creek, which are located on the east side of Bucks Lake off State Route 70/89 providing trail access from Quincy. Bucks Summit has a parking lot and restrooms. Big Creek provides parking via road shoulder pullouts along Bucks Lake Road and Big Creek Road. The trail system has one warming hut. Trails are groomed by the Mt. Hough Ranger District of the Plumas National Forest. Both staging area access roads (six miles on Buck Lakes Road and one mile on Big Creek Road) are plowed by Plumas County Road Department.

La Porte Trail System. The La Porte trail system is located east of Oroville on La Porte Road (Figure 6B, La Porte). A staging area with a large warming hut and restrooms is accessed from La Porte Road. The La Porte trail system offers 72 miles of groomed loop trails with views of Little Grass Valley Reservoir and the Feather River Canyon. La Porte trail elevations range from 4,900 feet to 6,600 feet. Four trailside-warming huts with wood stoves are available in addition to the trailhead warming hut. Trails are groomed by the Feather River Ranger District of the Plumas National Forest. One-half mile of plowed access on La Porte Road is provided by Plumas County Road Department.

Gold Lake Trail System. Gold Lake is located near the southern boundary of the Plumas National Forest near Graeagle on Gold Lake Highway (Figure 6C, Gold Lake) off State Route 89. Trailhead parking is provided via a parking lot accessed from Gold Lake Highway. The groomed trail follows Gold Lake Highway south to Gold Lake and into Tahoe National Forest connecting to the Bassetts trail system. Gold Lake is located in Lakes Basin and offers 10 miles of groomed trail ranging in elevation from 5,400 feet to 7,200 feet. Gold Lake trails are predominately located in Sierra County and trail grooming is contracted through Sierra County Public Works using volunteer groomers. The Plumas National Forest Beckwourth Ranger District maintains trail routes with signage and provides law enforcement. The Gold Lake trailhead is located in Plumas County. Four miles of Gold Lake Highway from State Route 89 to the trailhead is plowed by Plumas County Road Department.

2.3.6 Tahoe National Forest – American River, Yuba River, Truckee, and Sierraville Ranger Districts

Bassetts Trail System. The Bassetts trail system and trailhead parking are located off State Route 49 roughly 15 miles west of Sierraville in the Yuba River Ranger District (Figure 7A, Bassetts). Trailhead parking is provided off Gold Lake Road. Some of the Bassett area trails extend north to the Gold Lake area in the Plumas National Forest. Bassetts provides 82 miles of groomed trail on the Tahoe National Forest. Trails connect to the Little Truckee Summit trailhead. Trail elevations range from 5,700 feet to 7,800 feet. Bassetts is groomed by volunteer groomers, the Sierra Buttes Snow Busters, using the State's grooming machine. These volunteers receive OSV Program funds through Sierra County for supplies for the groomer, signs, satellite phone service, and for cleaning and supplying the restrooms. Plowed trailhead access is provided by Caltrans under contract to Sierra County.

Little Truckee Summit Trail System. The Little Truckee Summit trail system is accessed from three different trailhead parking areas: Yuba Pass Sno-Park on State Route 49 eight miles west of Sierraville (Figure 7A); Little Truckee Summit on State Route 89 at Jackson Meadow Road roughly 16 miles north of Truckee (Figure 7B, Little Truckee Summit); and Prosser Hill five miles north of Truckee (Figure 7B). Little Truckee Summit offers 138 miles of groomed trail with elevations ranging from 5,700 feet to 7,800 feet. Snowmobile trail grooming is done by a private contractor through the Sierra County Public Works and Transportation Department. Some snowmobile trail grooming is done under USFS volunteer agreements by private landowners living year-round off the groomed trail system. Plowed trailhead access is provided by Caltrans at all three trailheads; however only the Little Truckee Summit trailhead is plowed by OSV Program funds under contract to Sierra County. In the spring, temporary trailheads are set-up along the main groomed snowmobile route by plowing Jackson Meadow Road (Forest Route 07) out of Little Truckee Summit, to help provide better access for OSV users and decrease damage to the Jackson Meadow Road. Plowing of Jackson Meadow Road has historically been done by private contractor through Sierra County, however, this year (2010), plowing will be done by Sierra County. Winter rest-room cleaning and maintenance at all three locations is done with a combination of Tahoe National Forest OHV Ground Operations funds (Prosser Hill), sno-park funds (Yuba Pass Sno-Park), and OSV Program funds through Sierra County (Little Truckee Summit).

China Wall Trail System. The China Wall trail system and trailhead parking are located 12 miles northeast of Foresthill on Foresthill Road off of Interstate 80 near Auburn (Figure 7C, China Wall). Trailhead parking is provided via a parking lot accessed from Foresthill Road. The China Wall trail system provides 50 miles of groomed trail, a plowed trailhead, and a restroom maintained by the American River Ranger District. Trail elevations range from 5,000 feet to 7,200 feet. Unmarked routes follow Foresthill Road from which riders can take side trips to Humbug, Deadwood, and American Hill ridges. The groomed trails include the China Wall Staging Area to Road 66, Humbug Loop, Foresthill Divide Road, American Hill Loop (Road 13), Ford Point Trail and Tadpole Loop, Soda Springs Trail, and Duncan Y trail (Road 43). Placer County plows 3 miles of Foresthill Road and the trailhead parking.

2.3.7 Eldorado National Forest – Amador Ranger District

Silver Bear Trail System. The Silver Bear trail system, located 18 miles east of Jackson on State Route 88 between Silver Lake and Bear River Reservoir, has approximately 60 miles of groomed snowmobile trails (Figure 8, Silver Bear). This trail system, in operation since 1987, is the only groomed snowmobile trail system on the Eldorado National Forest. Trail elevations range from 5,700 feet to 8,000 feet. It can be accessed by the Iron Mountain Sno-Park, which has a restroom and parking strip along the highway shoulder. Some OSV users also stage out of a small parking area located near the Bear River Resort which is not maintained by OSV Program funds. Restroom service and refuse collection is maintained by the Amador Ranger District through the OSV Program. Snow removal (plowing) in the trailhead parking area is provided through state funding of sno-parks separate from the Project.

2.3.8 Stanislaus National Forest – Calaveras and Summit Ranger Districts

Lake Alpine, Spicer Reservoir, and Highway 108 Trail Systems. Stanislaus National Forest has 70 miles of signed, groomed trails accessible from three sno-park trailheads: Lake Alpine by the Bear Valley ski resort, Spicer Reservoir, and Highway 108. The Lake Alpine Sno-Park is located at the winter closure gate on State Route 4 just past the turnoff to Mt. Reba Ski Area in Alpine County, about 55 miles east of Angels Camp (Figure 9A, Lake Alpine and Spicer Reservoir). Lake Alpine trail elevations range from 7,200 feet to 8,700 feet. The Spicer Reservoir Sno-Park is located on the south side of State Route 4 at Spicer Road in Calaveras County, about 45 miles east of Angels Camp (Figure 9A). Trail elevations at Spicer Reservoir range from 6,200 feet to 7,100 feet. Together Lake Alpine and Spicer Reservoir trailheads access 40 miles of groomed trail on the Calaveras Ranger District. The Highway 108 Sno-Park is located from the winter closure gate on State Route 108, six miles east of Strawberry (Figure 9B, Highway 108) in the

Summit Ranger District. The Highway 108 trailhead accesses 30 miles of groomed trail with elevations ranging from 5,900 feet to 7,800 feet. All three trailhead parking areas have restrooms and additional restrooms open next to groomed trails. Cross-country skiing, snowshoeing, snow play, and snow camping also occur in these areas. Trail grooming at all three areas is provided by private contractors to the Calaveras and Summit Ranger Districts. Parking areas at all three trailheads are plowed under separate state funding of sno-parks.

2.3.9 Inyo National Forest – Mammoth and Mono Ranger Districts

Mammoth Lakes Area Trail System. The Mammoth Lakes Area trail system and Shady Rest trailhead are located between Mammoth Lakes and Lee Vining on U.S. Highway 395 (Figure 10, Mammoth Lakes). The Mammoth Lakes trail system is located off of State Route 203 while the June Lake trail system can be accessed via State Route 158. Approximately 80 miles of groomed and marked snowmobile trails exist on the Forest. Groomed trails are located in Smokey Bear Flat, Inyo Crater Lakes, Deer Mountain, and Bald Mountain. Trail elevations range from 7,300 feet to 9,100 feet. The Shady Rest trailhead which offers a plowed parking lot and four restrooms is maintained by the City of Mammoth separately from the OSV Program. A wide variety of terrain is available for recreation by OSVs from wide, open meadows to forested areas. The trails occur on both the west and east sides of U.S. Highway 395 with a tunnel beneath the highway connecting the trails.

2.3.10 Sierra National Forest – High Sierra Ranger District

Huntington Lake/Kaiser Pass (Eastwood), and Tamarack Ridge Trail Systems. Huntington Lake/ Kaiser Pass (Eastwood), and Tamarack Ridge are located on State Route 168, north of Shaver Lake (Figure 11, Huntington Lake/Kaiser Pass, and Tamarack Ridge). This area offers 240 miles of designated snowmobile trails, of which 209 miles are groomed throughout the winter season, along with 32 miles of designated cross-country ski trails. The Kaiser Pass (Eastwood) trailhead accesses 150 miles of looped trails. This trailhead provides a parking lot, restroom facilities, and a public telephone. The Huntington Lake trailhead services the same area as the Kaiser Pass trailhead and provides additional parking and restrooms. The Tamarack Ridge trailhead provides access to 90 miles of looped trails from a parking lot with restrooms. Trail elevations range from 4,900 feet to 9,000 feet. All three trailheads are designated as sno-parks and plowed by the High Sierra Ranger District under separate state funding of sno-parks.

The Sierra National Forest snowmobile trail system is linked together by a series of eight trail bridges over major streams and three highway crossings. A snowmobiler may park at any of the three snowmobile trailheads and have access to the entire trail system. Of the 32 designated trails, some are loop trails and many are destination trails to scenic overlooks and lakes. Most areas of the High Sierra Ranger District are open to snowmobiling.

2.3.11 Sequoia National Forest – Hume Lake, Western Divide, and Kern River Ranger Districts

Big Meadow/Quail Flat Trail System. The Big Meadow/Quail Flat trail system is located off State Route 198 (Generals Highway) in the Giant Sequoia National Monument near Kings Canyon National Park. The area has 30 miles of groomed and marked trails with another 50 miles of unmarked roadbed (Figure 12A, Hume Lake Ranger District). Trails range in elevation from 5,400 feet to 8,500 feet. Four parking areas are provided for winter recreation: one on State Route 180 north of Grant Grove (Cherry Gap) and three on the Generals Highway (Quail Flat, Big Meadow, and Upper Woodward). Plowed access is provided by Caltrans under contract to Sequoia National Forest. The USFS provides public restroom facilities at Quail Flat and Big Meadow. Trail grooming is provided by a private contractor to the Hume Lake Ranger District. Restrooms and a warming hut are maintained by the Hume Lake Ranger District. A groomed road from the Big Meadow and Upper Woodward trailheads provides snowmobilers access to Montecito Lake Resort which offers food, lodging, equipment rentals, ice skating and many other winter activities.

Snowmobile roads and cross-country ski trails are available from each of the four parking areas. There are intermittently groomed snowmobile roads available from the three trailheads on the Generals Highway. Snowmobile riding is not allowed off developed roads or on designated trail routes within the Giant Sequoia National Monument or in any designated wilderness areas. All snowmobile routes are open to skiers and snowshoers. There are also undeveloped and unmarked ski trails available and sledding and general snow play is permitted throughout the general forest area and at each of the four parking areas.

Quaking Aspen/Sugarloaf Trail System. The Quaking Aspen area is located off State Route 190 at its junction with the Western Divide Highway, 30 miles east of Porterville near Camp Nelson (Figure 12B, Western Divide Ranger District, Northern Half). Two trailheads, Quaking Aspen and Holby (Ponderosa), provide access to the trail system from this location. Trails extending north from these trailheads end at the Golden Trout Wilderness while trails extending south reach the Greenhorn Mountains and the Sugarloaf trailhead. Plowed access to Quaking Aspen and Holby is provided by Caltrans under contract to Sequoia National Forest. The Sugarloaf trailhead is accessed from State Route 155 off County Road M-9 near Posey (Figure 12C, Western Divide Ranger District, Southern Half). Tulare County plows 0.8 miles of County Road M-9 and the Sugarloaf trailhead. The trail system offers 100 miles of groomed trails. The summit elevation is just over 6,000 feet with trail elevations ranging from 5,800 feet to 8,000 feet. There is one trailside warming hut on the Western Divide trail north of the Quaking Aspen trailhead and restrooms at the Quaking Aspen and Holby trailhead parking areas. This trail system and its facilities are maintained by the Western Divide Ranger District. Most of the trails are within the Giant Sequoia National Monument. Snowmobile riding is not allowed off of roads within the Giant Sequoia National Monument, in any designated wilderness areas, or on designated trails. All snowmobile routes are open to skiers and snowshoers and other non-motorized users.

Kern Plateau Trail System. Kern Plateau trail system is located on Sherman Pass Road off Mountain Road 50 east of Johnsondale (Figure 12D, Kern Plateau Ranger District). The trails are accessed from the Kern Plateau-Westside (Sherman Pass) and Kern Plateau-Eastside (Kennedy Meadows) trailheads. The OSV trails are outside the eastern boundary of the Giant Sequoia National Monument. The area has 85 miles of groomed trails, 10 miles of ungroomed trails, and 30 miles of unmarked routes over 15,000 acres of suitable open area with riding elevations ranging from 7,800 feet to 9,990 feet at the top of Sherman Mountain. The typical trail elevation is roughly 8,400 feet. A trailside warming hut is available on Trail 101. The trail system is maintained by the Kern River Ranger District. Twelve miles on Sherman Pass Road and five miles on Kennedy Meadows Road from the USFS boundary to the trailhead are plowed by a private contractor to maintain trailhead access. Kennedy Meadows Road is located on the east side of the Sierra Nevada where snowfall is light and melts off quickly. Plowing on this road segment may occur only once or twice per year and in some years no plowing is required.

Table 2-1. Overview of OSV Program Activity

Project Location National Forest (NF) and County	Recreation Facility	OSV Program Funded Activity
Klamath NF, Goosenest Ranger District Siskiyou County, near Weed (Deer Mountain) and near Tennant (Four Corners Medicine Lake)	Deer Mountain and Four Corners Medicine Lake Snowmobile Parks	Groom 135 miles of trail, plow 32 miles of road and 2 trailheads, trail maintenance, facility maintenance, refuse collection, restroom service.
Modoc NF, Doublehead Ranger District Siskiyou County, near Lava Beds National Monument	Doorknob Snowmobile Park	Groom 52 miles of trail, plow 4 miles of road and 1 trailhead, service 2 restrooms, and refuse collection.
Shasta-Trinity NF, Shasta-McCloud Ranger Districts Siskiyou County, near McCloud	Pilgrim Creek Snowmobile Park	Groom 86 miles of trail, plow 8 miles of road and 1 trailhead, service 1 restroom, and refuse collection.
Lassen NF, Hat Creek Ranger District Shasta County near Latour State Forest and Lassen Volcanic National Park	Ashpan Snowmobile Area	Groom 35 miles of trail, plow 1 trailhead, service 1 restroom, and refuse collection.
Lassen NF, Eagle Lake Ranger District Lassen County, near Eagle Lake (Bogard) and Westwood (Fredonyer)	Bogard and Fredonyer Snowmobile Areas	Groom 160 miles of trail, plow 2 trailheads, service 2 restrooms and refuse collection
Lassen NF, Almanor Ranger District Plumas and Lassen Counties, near Chester (Swain Mountain) and Tehama County near Mineral (Morgan Summit)	Swain Mountain and Morgan Summit Snowmobile Areas	Groom 137 miles of trail, plow 0.25 miles of road and 3 trailheads, service 2 restrooms and refuse collection
Lassen NF, Almanor Ranger District Butte and Plumas Counties, near Jonesville and Lake Almanor	Jonesville Snowmobile Area	Groom 70 miles of trail, plow 7 miles of road and 1 trailhead
Plumas NF, Mt. Hough and Feather River Ranger District Plumas County near Quincy (Bucks Lake and La Porte) Plumas and Sierra Counties near Graeagle (Gold Lake)	Bucks Lake, La Porte, and Gold Lake Trail Systems	Groom 182 miles of trail, plow 11.5 miles of road and 4 trailheads, signing along trails, maintenance of 5 trailside warming huts and 3 trailhead restrooms and 1 warming hut.
Tahoe NF, Yuba River Ranger District Sierra County, near Sierraville	Bassetts and Little Truckee Summit Trail Systems	Groom 220 miles of trail, plow 13 miles of road and 2 trailheads, and service restrooms.
Tahoe NF, American River Ranger District Placer County, near Auburn	China Wall Trail System	Groom 50 miles of trail, plow 3 miles and 1 trailhead, service 1 restroom, and refuse collection.
Eldorado NF, Amador Ranger District El Dorado County, near Jackson	Silver Bear Trail System	Groom 60 miles of trail and service 3 restrooms.

Table 2-1. Overview of OSV Program Activity		
Project Location National Forest (NF) and County	**Recreation Facility**	**OSV Program Funded Activity**
Stanislaus NF, Calaveras and Summit Ranger Districts Alpine County, near Bear Valley (Lake Alpine) Tuolumne County, near Dardanelle (Spicer) and Strawberry (Highway 108)	Lake Alpine, Spicer Reservoir, and Highway 108 Trail Systems	Groom 70 miles of trail, service 3 restrooms, and refuse collection.
Inyo NF, Mammoth and Mono Ranger Districts Mono County, near Mammoth Lakes	Mammoth Lakes Area Trail System	Groom 80 miles of trail.
Sierra NF, High Sierra Ranger District Fresno County, near Lakeshore	Huntington Lake, Kaiser Pass (Eastwood), and Tamarack Ridge Trail Systems	Groom 209 miles of trail and service 3 restrooms.
Sequoia NF, Hume Lake Ranger District Fresno and Tulare Counties, near Wilsonia	Big Meadow/Quail Flat Trail System	Groom 30 miles of trail, plow 4 trailheads, service 1 restrooms, and maintain 1 warming hut.
Sequoia NF, Western Divide Ranger District Tulare County, near Camp Nelson (Quaking Aspen) and near Posey (Sugarloaf)	Quaking Aspen/Sugarloaf Trail System	Groom 100 miles of trail, plow 0.8 miles and 3 trailheads, service 2 restrooms, and maintain 1 warming hut.
Sequoia NF, Kern River Ranger District Tulare County, near Johnsondale	Kern Plateau-Westside (Sherman Pass) and Eastside (Kennedy Meadows) Trail System	Groom 85 miles of trail, plow 17 miles of road and 2 trailheads, and maintain 1 warming hut.

Source: CDPR, OHMVR Division 2009

2.4 PROJECT CHARACTERISTICS

The OSV Program would provide funding to national forests and county road departments for implementation of the direct actions described below. The proposed OSV Program funding for ten winter seasons (2010/11 through 2019/20) represents a continuation of funding for routine maintenance of winter recreation facilities in the national forests and counties that first started in 1982 and has been occurring at all locations for at least 14 years.

No immediate changes to the OSV Program are proposed by the Project; thus, the snow removal (plowing and blowing), trail grooming, and maintenance activities described below are the same as what has been occurring since 1996 when the last trail system opened. The potential for future changes to the OSV Program during the next ten years, such as the addition of new trailheads or groomed trail systems, is described below in OSV Program Growth Levels, Section 2.7 below.

The length of the snow season varies from year to year dependent upon snow fall. Accordingly, annual plowing and grooming activities funded by the Project would vary over the 10-year project period. Heavy snow years would require more plow days and grooming hours than years with light snowfall. In light snow years, trails at lower elevations may not be groomed, reducing the annual number of miles groomed and hours of equipment operation.

2.4.1 Grooming Trails

Groomed trails are designated for winter recreation and OSV use by the forest plans governing the national forests. All snow groomed trails are existing dirt or gravel trails or paved roads. These trails are used in the summer for OHV and non-motorized recreation. All project trails have been used annually for winter recreation for since 1982. The purpose of the grooming program is to provide a high quality snowmobile trails system that is smooth and stable for the rider. The groomed trail is designed so that the novice rider can use it without difficulty.

The grooming season generally begins in mid-December and continues through March. Start and stop times vary per trail location dependent upon snow presence. Grooming starts in most locations with minimum snow depth of 12 inches. Eldorado, Stanislaus, and Inyo National Forests require a minimum snow depth of 18 inches and Sequoia National Forest requires a minimum depth of 24 inches. Trails are prioritized for grooming based on visitor use. Grooming on priority trails occurs several times per week and after significant storms. The total hours of trail grooming occurring expected at each site for an average season is shown in Table 2-2. Trail grooming occurs as soon as possible after a storm in which snow accumulations have been substantial. The ideal air temperature for grooming is 35 degrees Fahrenheit or less with the temperature dropping. Wet snow requires a lower temperature to set and is best groomed at night. Heavy, wet snow at the end of a warm storm is packed as soon as possible with most of the grooming at night regardless of the temperatures. Grooming generally occurs at night (between 4:00 PM and 6:00 AM) except when circumstances require daytime grooming. Daytime grooming occurs when the snowmobile traffic is lightest so the trail surface has time to harden. Daytime grooming is generally not conducted on weekends or during periods of heavy use except for emergencies or when the situation otherwise precludes grooming during periods of low use.

Trails are groomed to a minimum width of 10 feet and up to 30 feet wide in the more heavily used areas such as near trailheads. Groomed trail width is determined by variety of factors such as width of the underlying road bed, width of grooming tractor, heavy two-way traffic on the trail, and trail corners. Trail width is not groomed beyond width of underlying roadbed. Where the terrain allows, main ingress and egress trails that connect to the trailhead are groomed to 18 feet wide or greater to facilitate the added traffic. Moguls (snow mounds) are cut off as deep as possible (halfway down or more) to fill the low spots and voids in the trail. Moguls are not cut to the bottom if it will result in bringing dirt into the snow. Snowdrifts are groomed as level as possible.

Snowcats are operated at speeds in the range of three to seven miles per hour. The vehicle is operated with warning lights on at all times. The maximum hours of equipment operation is generally a 12-hour day during peak season (Table 2-2).

Trail grooming is conducted in accordance with 1997 Snowmobile Trail Grooming Standards set by the OHMVR Division as summarized in Table 2-3. Individual national forests may have their own policies such as the 2007-2008 Grooming Program Policy prepared as part of the Memorandum of Understanding between California and Nevada Snowmobile Association and Eldorado National Forest – Amador Ranger District.

Table 2-2. OSV Program Annual Grooming Operations

National Forest	Grooming Location	Annual Groomed Miles	Total Groom Days	Annual Snowcat Hours	Max Day Hours
Klamath	Deer Mountain and Four Corners	1564	37	272	16
Modoc	Doorknob	--			
Shasta-Trinity	Pilgrim Creek	1440	33	240	13
Lassen	Ashpan	1743	n/a	249	12
Lassen	Bogard and Fredonyer	5076	n/a	680	12
Lassen	Swain Mountain	660	n/a	94	12
Lassen	Morgan Summit	900	n/a	300	12
Lassen	Jonesville	2222	34	420	25
Plumas	Bucks Lake	949	38	409	12
Plumas	La Porte	744	34	207	12
Plumas	Gold Lake	--			
Tahoe	Bassetts	1050	n/a	175	12
Tahoe	Little Truckee Summit	3600	n/a	600	15
Tahoe	China Wall	823	21	137	10
Eldorado	Silver Bear	900	16	150	10
Stanislaus	Lake Alpine and Spicer	356	13	59	12
Stanislaus	Highway 108	910	22	175	12
Inyo	Mammoth Lakes	1264	31	195	9
Sierra	Huntington Lake/ Kaiser Pass	852	38	181	12
Sierra	Tamarack Ridge	930	28	178	12
Sequoia	Big Meadow/Quail Flat	165	7	41	12
Sequoia	Quaking Aspen/Sugarloaf	71	4	58	12
Sequoia	Kern Plateau	199	7	128	12
	Total	**26,418**		**4,948**	

Notes:
Based on 2008/2009 or 2007/2008 winter season grooming data submitted to OHMVR Division.
Maximum Day assumed to be 12 hours unless otherwise specified.
Trails in Modoc National Forest are groomed by Klamath and Shasta Trinity National Forests. Snowcat hours and miles for Modoc are included in Klamath and Shasta totals.
Trails in Gold Lake are groomed by Tahoe National Forest. Snowcat hours and miles for Gold Lake are included in Bassetts totals.
(Appendix E, Table AQ-14).

Source: USFS 2009

Table 2-3. 1997 Snowmobile Trail Grooming Standards

Operators shall be trained and directed by a Grooming Coordinator.

Identify hazards in advance of grooming, preferably in Autumn before snow falls.

Begin grooming when the snow depth is at least 12 to 18 inches.

Typical grooming season is from December to March.

Operate the snow tractor on approved designated trails only.

Maintain a 10-foot vertical clearance from potential obstructions.

Limit grooming speeds to between three to seven miles per hour.
Groom trails to a minimum of 10 feet wide with a typical width of 10 to 14 feet.

Source: CDPR, OHMVR Division 1997

Trails are typically groomed using a snowcat with a blade and tiller attachments. OHMVR Division owns 15 snowcats which are stationed near the OSV Program trail locations. Eight additional snowcats are owned by private contractors on trails in the Sierra National Forest, Stanislaus National Forest, and Tahoe National Forest. A list of the state and privately owned grooming equipment used for the OSV Program is presented in Table 2-4. Grooming is performed by USFS staff, private contractors, or volunteers.

Table 2-4. OHMVR Division OSV Program Grooming Equipment

National Forest	Location	TIER	Type
Klamath	Four Corners	0	Piston Bully 260D
Shasta-Trinity	Mt. Shasta	0	Piston Bully 260D
Lassen	Ashpan	3	Piston Bully 400
Lassen	Fredonyer	2	Piston Bully 200 Edge
Lassen	Bogard/Swain	3	Piston Bully 400
Lassen	Morgan Summit	1	Piston Bully 200
Lassen	Jonesville	0	Bombardier*
Lassen	Jonesville	0	Tucker*
Plumas	Bucks Lake	0	Bombardier BR 400
Plumas	La Porte	0	Bombardier BR 400
Tahoe	Bassetts	0	Piston Bully 300
Tahoe	Little Truckee Summit	1	Bombardier MP 275*
Tahoe	China Wall	1	Piston Bully 200
Eldorado	Silver Bear/Iron Mountain	0	Piston Bully 260
Stanislaus	Lake Alpine	0	Bombardier BR 400*
Stanislaus	Spicer Reservoir	0	Bombardier BR 400*
Stanislaus	Highway 108	1	Bombardier BR 200*
Inyo	Mammoth	1	Piston Bully 200
Sierra	Shaver Lake	0	Piston Bully 240D
Sierra	Huntington Lake	0	Bombardier BR 400*
Sequoia	Montecito Lake Resort		n/a
Sequoia	Kernville	0	Piston Bully 240D
Sequoia	Hot Springs	0	Piston Bully 240D

* Equipment owned by contract groomers. All other equipment is state owned.
"Tier" refers to engine age class and pertains to compliance with CARB diesel off-road emissions regulations.

Tier 0 1988-1995
Tier 1 1996-2002
Tier 2 2003-2006
Tier 3 2007-2010
Tier 4 2011-2013
Tier 5 2014-

Source: CDPR, OHMVR Division 2009

The OHMVR Division's snowcat fleet is subject to emission regulation by the California Air Resources Board (CARB) as off road equipment. CARB sets an emission limit for the vehicle fleet as a whole rather than for individual pieces of equipment. Based on the total horsepower of the vehicle fleet, and the model and year of the individual equipment within the fleet, CARB determines how much horsepower per year must be repowered, retrofitted, or retired. The OHMVR Division then determines what modifications to make to its fleet in order to satisfy CARB requirements. Accordingly, the snowcat vehicle fleet identified in Table 2-4 would be modified throughout the 10-year project period. The retrofit and replacement schedule is shown in Table 2-5. Six snowcats were retrofitted in 2009 and are included in Table 2-4. Starting in 2010, nine snowcats will be replaced over a five-year period.

Table 2-5. OHMVR Division Snowcat Vehicle Fleet Replacement Plan

Year	OHMVR Division Action	Equipment
2010	Vehicle Replacement	Klamath NF, Four Corners PB260 Shasta Trinity NF, Mt. Shasta PB260
2011	Vehicle Replacement	Tahoe NF, Bassetts PB300 Eldorado NF, Iron Mountain PB260
2012	Vehicle Replacement	Plumas NF, Bucks Lake BR400 Plumas NF, LaPorte BR400
2013	Vehicle Replacement	Sierra NF, Shaver Lake PB240 Sequoia NF, Kernville PB240
2014	Vehicle Replacement	Sequoia NF, Hot Springs PB240

Source: CDPR, OHMVR Division 2009

2.4.2 Plowing Access Roads and Parking Areas/Trailheads

Snow removal on access roads and trailhead parking areas, serving the OSV Program trail systems, occurs several times during storm events as necessary dependent upon weather conditions. Typical snow removal equipment used includes a motor grader or a snowplow blade mounted on a standard dump truck or loader, and a snow blower. Snow removal may be done by USFS staff, a private contractor, or by the California Department of Transportation (Caltrans). Trailheads that are located on State Routes are plowed by Caltrans under separate contracts with Lassen and Sequoia National Forests and Sierra County. Trailheads that are located on County Roads are plowed by local county road departments or their contractors. The plowed roads and contractors funded by the OSV Program are listed in Table 2-6. OSV Program funding of snow removal presently occurs on 97 miles of paved roads and 17 of the 34 trailhead parking areas. The typical hours of snow removal equipment operation per OSV Program location are estimated in Table 2-7.

Table 2-6. OSV Program, Plowed Access Roads And Trailheads

National Forest/Trailhead	Contract Agency/ Service Provider	Access Road	Plowed Length
Klamath/Deer Mountain	Klamath NF/private	Forest Route 19	4 miles
Klamath/Four Corners	Klamath NF/private	Red Rock Road	17 miles
Klamath/Four Corners	Klamath NF/private	Forest Route 15	11 miles
Modoc/Doorknob	Modoc NF/Lava Beds	Forest Route 49	4 miles
Shasta-Trinity/Pilgrim Creek	Shasta-Trinity NF	Forest Route 13	8 miles

Table 2-6. OSV Program, Plowed Access Roads And Trailheads

National Forest/Trailhead	Contract Agency/ Service Provider	Access Road	Plowed Length
Lassen/Ashpan	Lassen NF/Caltrans	State Route 89/44	Trailhead
Lassen/Bogard	Lassen NF/Caltrans	State Route 44	Trailhead
Lassen/Fredonyer	Lassen NF/Caltrans	State Route 36	Trailhead
Lassen/Swain Mountain	Plumas County	County Road A-21	Trailhead
Lassen/Morgan Summit	Lassen NF/Caltrans	State Route 89/36	Trailhead
Lassen/Chester-Lake Almanor	Plumas County	Forest Route 10	0.25 mile
Lassen/Jonesville	Butte County/private	Humboldt Road	7 miles
Plumas/Bucks Summit	Plumas County	Bucks Lake Road	6 miles
Plumas/Big Creek	Plumas County	Big Creek Road	1 mile
Plumas/La Porte	Plumas County	La Porte Road	0.5 mile
Plumas/Gold Lake	Plumas County	Gold Lake Hwy	4 miles
Tahoe/Bassetts	Sierra County/Caltrans	State Route 49	Trailhead
Tahoe/Little Truckee Summit	Sierra County/private	Forest Route 07	13 miles
Tahoe/Little Truckee Summit	Sierra County/Caltrans	State Route 89	Trailhead
Tahoe/China Wall	Tahoe NF/Placer County	Foresthill Road	3 miles
Eldorado/Iron Mountain	Sno-Park	State Route 88	--
Stanislaus/Lake Alpine	Sno-Park	State Route 4	--
Stanislaus/Spicer Res.	Sno-Park	State Route 4	--
Stanislaus/Highway 108	Sno-Park	State Route 108	--
Sierra/Huntington Lake	Sno-Park	State Route 168	--
Sierra/Kaiser Pass	Sno-Park	State Route 168	--
Sierra/Tamarack Ridge	Sno-Park	State Route 168	--
Sequoia/Big Meadow	Sequoia NF/Caltrans	State Route 180	Trailhead
Sequioa/Quail Flat	Sequoia NF/Caltrans	State Route 180	Trailhead
Sequoia/Cherry Gap	Sequoia NF/Caltrans	State Route 180	Trailhead
Sequoia/Upper Woodward	Sequoia NF/Caltrans	State Route 180	Trailhead
Sequoia/Quaking Aspen	Sequoia NF/Caltrans	State Route 190	Trailhead
Sequoia/Holby	Sequoia NF/Caltrans	State Route 190	Trailhead
Sequoia/Sugarloaf	Sequoia NF/Tulare County	County Road 9	0.8 mile
Sequoia/Kern Plateau Westside	Sequoia NF/private	Sherman Pass Road	12 miles
Sequoia/Kern Plateau Eastside	Sequoia NF/private	Kennedy Meadows Road	5 miles

Notes:

Caltrans plows State Routes under separate state transportation funding. Trailheads on State Routes are plowed by Caltrans using OSV Program funds.

Swain Mountain trailhead is plowed by Plumas County using OSV Program funds. County road access to trailhead is plowed by Lassen County through separate county road department funding.

Trailheads which are also designated as sno-parks are plowed under separate state funding for sno-park recreation.

Source: CDPR, OHMVR Division 2009

Table 2-7. OSV Program Annual Snow Removal Operation

National Forest/Trailhead	Total Days	Plow Truck, Tractor, and Grader Hours	Blower Hours	Max Day Hours All
Klamath/Deer Mountain and Four Corners	14	61	0	7
Modoc/Doorknob	14	84	n/a	8
Shasta-Trinity/Pilgrim Creek	25	234	--	16
Lassen/Ashpan, Bogard, Fredonyer, and Morgan Summit	*			
Lassen/Swain Mountain and Chester-Lake Almanor	8	21	0	6
Lassen/Jonesville	18	90	90	18
Plumas/Bucks Summit and Big Creek	60	275	85	8
Plumas/La Porte	13	18	6	2
Plumas/Gold Lake	49	709	32	6
Tahoe/Bassetts	n/a	n/a	n/a	n/a
Tahoe/Little Truckee Summit	n/a	124	0	8
Tahoe/China Wall	15	28	4	2
Eldorado/Iron Mountain	**			
Stanislaus/Lake Alpine, Spicer, and Highway 108	**			
Sierra/Huntington Lake, Kaiser Pass (Eastwood), and Tamarack Ridge	**			
Sequoia/Big Meadow, Quail Flat, Cherry Gap, and Upper Woodward	*			
Sequoia/Quaking Aspen, Holby (Ponderosa)	*			
Sequoia/Sugarloaf	n/a	n/a	n/a	n/a
Sequoia/Kern Plateau-Westside and Eastside	42	215	0	11
Total	**258**	**1859**	**217**	**92**

Notes:
* Plowing provided by Caltrans. Data not available.
** Plowing funded through Sno-Park recreation program separate from OHMVR Division OSV Program
Data from 2008/2009 season records except as noted.
Modoc NF estimate of plowing once per week during season. Assumes average plow day of 6 hours.
Shasta NF based on 2007/2008 data to represent a more accurate level of plowing activity in an average snow year. 2008/09 had 5 plow days and 56 total hours.
n/a = not available
(Appendix E, Table AQ-15)

Source: USFS 2009

Snow removal equipment involved in the OSV Program is not dedicated to the funded activities and is part of several vehicle fleets maintained by federal, state, local, or private entities. Fleet composition is not fixed from year to year and will vary throughout the season. The snow removal component of the OSV Program includes truck mounted plows and snow blowers; some of the latter may be dedicated snow removal equipment.

CARB established regulations requiring strict emissions reductions for nitrogen oxides (NOx) and particulate matter (PM) for new equipment, and setting a schedule for replacement or retrofit for on road heavy trucks. The plows used in snow removal are general purpose and are subject to emissions reduction. Snow blowers may be exempt if they are dedicated solely to use for snow removal. As a practical matter, newer diesel engines will share the reduced emissions tendency and so even dedicated snow removal equipment will likely have a reduced emissions profile in the future as newer equipment replaces older equipment. Projected Project-associated air pollutant emissions discussed in Air Quality, Chapter 4.0 reflect assumptions for cumulative fleet emissions reductions that will occur over the 10-year OSV Program period.

2.4.3 Facility Maintenance

The OSV Program provides funds for the servicing of trailhead restrooms, garbage collection, and sign maintenance and replacement. At some sites, these actions are State funded through the OSV Program and at other sites these actions are federally funded through the USFS. Garbage is typically collected twice a week during the peak of the grooming season using one person and a standard pickup truck. Most trailheads funded by the OSV Program have vault toilets rather than flush toilets. In addition to periodic cleaning of the restrooms (sweeping, cleaning, and stocking toilet paper), the vault toilets are pumped as needed. Pumping is typically done under contract with a private contractor. Many of the trail systems have warming huts which are wood or fiberglass structures with a wood-burning stove at its center and bench seating for 10 to15 people. Warming huts are cleaned and stocked with firewood by the USFS or volunteers.

Trail route signs are posted and maintained throughout the OSV areas to assist users with route location and orienteering. Signs are also clearly posted to identify closed areas and dissuade illegal trespass. Trail marker signs are placed along popular routes as well as at the periphery of closed areas. Barriers may be used to block access, if monitoring indicates that OSV use is occurring in closed or rehabilitating areas despite signing. Individual forest roads are marked with small wooden signs at intersections to further provide the public and agency personnel with locational information. Informational and regulatory signs and barriers are replaced as needed.

Preseason trail maintenance occurs periodically along all groomed trail routes. Groomed trails are typically used in summer by OHV and are kept clear of debris. Tree trimming occurs in summer months to maintain trails for OHV recreation. However, winter grooming requires a greater vertical clearance to be maintained for snowcats due to operation on an elevated snowpack. Light tree trimming can be required to maintain a vertical clearance limit of 12.5 feet for snowcats. Trails are checked in the fall before the first snow and obstructions are removed before trail grooming begins. Foreign material along the groomed areas is removed beyond the clearing limits by the groomer operator. Material that cannot be removed or rerouted around safely is brought to the attention of the grooming coordinator and flagged by the groomer operator as a hazard. All down trees are removed unless snow depth makes it impractical. Preseason trail maintenance is federally funded at some trail sites through the USFS and State funded by OHV Trust Funds (either through the Grants Program or the OSV Program) at other sites.

Maintenance of restroom and warming hut facilities do not result in a physical change in the environment. Trail route markers are installed on Carsonite posts (flexible fiberglass marker) which can be pounded into the ground with a mallet with very little ground disturbance. Tree trimming for preseason trail maintenance involves removal of annual vegetative growth along forest routes using hand tools and a bucket lift truck. Trimmed vegetation is removed from trail by a haul truck. All tree trimming work occurs along existing forest roads and does not modify habitat values or change the use of the area. The maintenance activities associated with the OSV Program do not have the potential for significant environmental impacts and therefore are not considered further.

2.4.4 Administrative Purchases and Support

The OSV Program includes periodic funding of national forests and local agencies to provide support services for winter trail recreation outside of the grooming, plowing, and facility maintenance services described above. Funding of additional administrative services may include equipment purchases and maintenance (snowmobiles, trailers, blowers, etc.) used by national forest staff during monitoring and maintenance activities, information kiosks, and trail maps and brochures. This administrative support may also include supplemental funding for national forest staff for activities such as visitor contacts, facility cleaning maintenance, and end of the season monitoring along trail routes to check for indications of soil erosion, resource damage, or trespass into restricted areas from OSV use. These administrative services are funded through the Grants Program as described below in Section 2.9.1. These grant-funded OSV activities are one-time commitment of funds to a grant applicant and do not represent a recurring OSV Program activity. Whereas the Budget Change Proposal (BCP) funded annual OSV Program activities of grooming, plowing, and maintenance occur on a set system of trails and trailheads with specific agencies (see Section 2.3), the Grants Program funded OSV activity can be provided to other national forests or local agencies. These administrative actions do not result in direct or indirect physical changes to the environment and do not create access to or subsequently enable recreational use of winter trails. Therefore, these actions are not subject to further consideration in this environmental analysis (CEQA Guidelines, Section 15378).

2.5 RELATED ACTIONS

Separate from the State funding of the OSV Program project activities described above, the USFS supports the OSV Program by funding law enforcement and public education and works with CDPR to ensure resource protection is implemented in each national forest. These activities are described below. These activities do not have a physical effect on the land and are not considered further in this environmental analysis except to the extent they are relevant to addressing potential effects of the OSV Program.

<u>Law Enforcement Activities</u>. Most of the national forest’s law enforcement plans (LEPs) include coverage of OSV activities. The LEPs are designed to provide direction and guidance to USFS OSV managers and employees with regards to the operation of national forest law enforcement OSV activities. Additionally, the LEPs supplement direction found in the Regional LEPs and the National Forest Land Resource Management Plans (LRMPs; see Land Use Plans and Policies, Section 4.0). The forests actively investigate and enforce OSV laws and regulations related to the National Forest System, California Vehicle Code (CVC), and the Public Resources Code (PRC). The primary emphasis of the OSV Law Enforcement Program is first, prevention, and second, enforcement of applicable laws and regulations found in the United States Code, the Code of Federal Regulations, the CVC, and PRC.

The broad mission of law enforcement efforts on the national forest is to protect employee and public safety, and natural resources. Law enforcement efforts on individual forests are based largely on an approach of recognizing or identifying problems and then acting to resolve them.

Issues are identified and prioritized based on an analysis of potential threats to public safety or resource damage.

Patrol Captains work with Forest Supervisors and District Rangers to develop enforcement plans and ensure identified law enforcement needs within the forest are met. Patrol Captains in conjunction with line officers have the discretion to allocate resources throughout the forest in order to meet priority needs. Law Enforcement Officer (LEO) staffing levels on national forests are generally static between seasons whereas Forest Protection Officer (FPO) staffing levels may vary with the season

<u>Public Education</u>. Information regarding OSV opportunities and regulations is available at each of the Forest's visitor centers. Maps and informational pamphlets are provided free-of-charge to the public depicting popular route locations and closed areas. The written material also explains applicable State and Federal regulations and emphasizes the "Tread Lightly" message. Several popular staging areas have informational kiosks with maps and resource protection literature posted.

<u>Resource Protection</u>. Management Actions would be undertaken concurrent with the OSV Program to protect sensitive biological and soil resources as described below in Section 2.8. Management Actions addressing special-status plant and wildlife species are also listed in Biology (see Chapter 5.0). Management Actions addressing soil erosion are identified in Hydrology (Chapter 6.0). Additionally, several focused wildlife studies investigating OSV recreation impacts on northern spotted owls and regional vertebrate assemblage are ongoing by the Pacific Southwest Region of the USFS. Results from all the studies are expected in 2010. A study investigating OSV and OHV impacts on martens was completed in 2007 (Zielinski et al. 2007).

2.6 Indirect Recreational Uses Facilitated by OSV Program

The proposed Project facilitates winter recreational use of the national forest trail systems identified in Table 2-1. Designated trails are predominately maintained for snowmobile use; however, other OHV users on a limited basis, cross-country skiers, and snowshoers can also use the trailhead parking areas and groomed trail systems. Snowmobiling also occurs in open riding areas within the national forests which are accessed from the groomed trail system. These recreational activities, both motorized and non-motorized, are considered indirect effects of the proposed project activity, which is maintaining the facilities (roads, parking, restrooms, warming huts, and trails) to provide public access to and availability of the winter recreation sites. Wintertime recreation activities have been occurring annually at these project sites since early the 1990s.

CEQA requires the indirect effects of project activities to be addressed in the environmental analysis. The environmental effects of winter use recreation that result from the Project as described below are considered in this document.

2.6.1 OSV Recreation

2.6.1.1 Winter Visitor Survey

In 2009, CDPR in association with California State University Sacramento conducted a pilot visitor survey at ten OSV Program trailheads and one additional trailhead (Hope Valley, which is operated as a sno-park) to obtain accurate, scientifically-collected baseline information on winter trail use. The surveys were conducted over a two-month period during winter 2009. The surveyed trailheads represent the northern and central geographic areas of the OSV Program project sites – from Deer Mountain in Klamath National Forest at the northern end of the Project Area to Highway 108 in Stanislaus National Forest at the southern end. In all, 413 individuals participated in the surveys representing groups totaling 1,732 visitors to the trailheads.

The survey employed a representative number and geographic distribution of trailheads and a randomized schedule of survey dates that included both weekdays and weekends throughout the winter season. A very strong response rate, with over 85% of invited visitors agreeing to participate, resulted in a high degree of confidence in the survey results. The survey explored visitor characteristics, visitor use levels, types of recreation occurring, details on OSV equipment use, the range and speed of OSV travel, observation of and attitudes toward problem behaviors, the origins of visitors traveling to the trailheads, as well as how plowing and grooming affect visitor choices. The full survey results are presented in Appendix A.

According to the 2009 Winter Trailhead Survey, snowmobiling is by far the predominant activity by visitors at the Project trailheads. Approximately 89% of visitors surveyed reported snowmobiling, 18% reported general snow play, and 14% reported engaging in cross-country skiing and snowshoeing. Other very popular activities included sledding/tubing and snowboarding (Appendix A, Table 18).

2.6.1.2 Visitor Use Levels

OSV use is the predominant recreational use at each trailhead, with non-motorized recreation concentrated at popular locations such as Iron Mountain in Eldorado National Forest. By providing plowed access and parking and groomed riding trails, the OSV Program facilitates OSV use of the project trailheads and riding areas. Participants in the Winter Trailhead Survey were asked whether their use of the trailhead for snowmobiling would change if plowing or grooming services were not provided (see Appendix A, Tables 48 and 49). Roughly half (50 to 54%) of those surveyed said they would snowmobile less or not at all. Almost one-third (27 to 30%) responded they would continue to use the trailheads regardless. A small fraction (3 to 5%) indicated their use of the trailhead would increase in the absence of these services. No response to this question was given by 15% of those surveyed. Based on these results, it is evident the OSV Program project facilitates OSV use of the trailheads for at least half of the survey participants. The plowing and grooming activities of the OSV Program support higher OSV levels at trailheads than what would otherwise occur. For the purposes of the EIR, it is assumed that two-thirds of the existing 2010 baseline level and projected 2020 levels are attributed to the OSV Program.

The OSV Program trail systems attract roughly 3,700 snowmobiles throughout the Project Area on a maximum day from OSV Program-funded trailheads (plowed parking and restrooms) as well as other non-program parking areas based on observed parking demand (Table 2-8). Annual OSV usage is estimated at approximately 159,000 user-days based on a 14 week season from December through mid-March, which broadly assumes heavy use on weekends and holidays and light use during weekdays. Parking areas shared with sno-parks likely have a lower number of machines per vehicle due to the presence of non-motorized visitors. Vehicles parking at popular OSV trailheads can have trailers carrying up to four OSVs. Estimates for maximum day and season totals assume an average of two OSV per parked vehicle. Roughly 79,000 vehicles per year visit the trail system parking areas. Assuming a vehicle occupancy of two to three persons, the trail systems and parking serve upwards of 200,000 visitors per year.

Actual use levels at each trailhead depend upon snow conditions which in California vary greatly per season and per geographic region within the same year. These estimated use level assumptions are based on observed trailhead parking capacities and overflow conditions during both weekday and weekend days by USFS staff and visitor surveys conducted for the 2009 Winter Trailhead Visitor Survey.

Table 2-8. 2009 OSV Program OSV Visitor Use Levels

National Forest	Parking Capacity	Max Day Vehicles Parked*	Seasonal OSV Use-days**
OSV Program Trailheads			
Klamath	95	46	5,506
Modoc	20	15	1,510
Shasta-Trinity	25	25	2,300
Lassen	152	106	10,948
Plumas	145	280	22,250
Tahoe	97	202	15,854
Eldorado	30	15	1,770
Stanislaus	330	480	40,260
Sierra	230	230	21,160
Sequoia	83	76	7,174
Subtotal	**1,207**	**1,475**	**128,732**
Other Non-Program Parking Areas			
Tahoe	48	43	4,086
Sierra	75	75	6,900
Inyo***	172	226	17,152
Sequoia	16	22	1,868
Subtotal	**311**	**366**	**30,006**
Total	**1,518**	**1,843**	**158,738**

Notes:
*Max Day is based on conditions observed by USFS staff
**Season is from mid-December through March (14 weeks). Seasonal total assumes 33 weekend/holidays of observed maximum day and 65 weekdays at 20% capacity. Assumes 2 OSV per average vehicle parked.
***Inyo NF notes that parking area fill multiple times in a day with some non-motorized visitors returning 2x and some staying only 1 hour. Max Day vehicles and Seasonal OSV use-day estimate assume 50% of parking is OSV use for Inyo parking areas.

Source: Data USFS 2009; Calculations TRA Environmental Sciences, Inc. 2010

2.6.1.3 Visitor Use Characteristics

The Winter Trailhead Visitor Survey results showed visitor use characteristics, used in this EIR, as a basis for assessing the indirect Project effects on winter recreation. The survey results provide an indication of visitor use levels at the trailheads, the types of recreation occurring at the trailheads, the speed of OSV travel, and the point of origin for visitors traveling to the trailhead. A summary of the visitor use characteristics used in the EIR to assess the indirect effects of OSV use is presented in Table 2-9.

A 1997 survey of California snowmobile users by the OHMVR Division found the majority of users (83%) traveled less than 80 miles in a single day (CDPR 1998). The same travel range was also identified by OSV organizations for present day riders. These sources show that riding habits remain consistently around 80 miles as a maximum roundtrip travel range. Without groomed conditions to start from, the range of OSV travel from the trailheads would likely be smaller. Distance and speed of travel is influenced by trail conditions. Roughly three-quarters of OSV users spend at least 40% of their riding time on the groomed trails (Table 2-9). Groomed trails enable higher OSV travel speeds due to smooth packed snow surface and greater fuel efficiency. Travel off trail on slopes and in soft powder conditions reduces both speed and fuel efficiency. Thus the range of OSV travel depends upon the riding habits of the individual. A small minority (10%) ride almost exclusively (≥81% of the time) off trail (Appendix A, Table 21).

Table 2-9. Trailhead Visitor Characteristics For EIR Analysis

Point of Origin	100 miles from trailhead (approximate)
Miles Traveled	80 miles or less*
Speed	40 mph average
Group Size	4 people per group
Recreation Type	89% OSV **
OSV Engine Type	96% 2-stroke, 4% 4-stroke
Hours on Snow	6 hours per day
On-trail vs. Off-trail Riding Time	73% on trail 40% to 100% of riding time 19% off trail 60% to 100% of riding time
Night Use of Trail	29%

Notes:

* Based on owner survey of snowmobiles registered by California Department of Motor Vehicles (CDPR 1998) and OHMVR Division knowledge of current riding habits.

** Represents an average over all trailheads in Survey. Snowmobiling was predominant at all surveyed trailheads (84 to 100%) except at Iron Mountain where snowmobiling was 57%

Source: Roloff et. al 2009; CDPR 1998

2.6.2 Non-Motorized Recreation

The OSV Program trail systems in three national forests share trailhead parking with non-motorized snow play areas designated as sno-parks by the CDPR. Sno-parks are maintained by CDPR under separate funding from the proposed OSV Program. At shared sno-park/OSV Program trailheads, the parking areas that provide access to the groomed trail system are plowed by Caltrans using sno-park funds. Restroom service and garbage collection at these trailheads are provided through the OSV Program. The seven OSV Program trailheads which share sno-park parking as described above are in Eldorado National Forest (Iron Mountain), Sierra National Forest (Huntington Lake, Kaiser Pass, and Tamarack Ridge), and Stanislaus National Forest (Lake Alpine, Spicer Reservoir, Highway 108).

Due to shared trailhead parking with the sno-parks and proximity of the snow play areas to groomed trails, it is possible that more non-motorized recreation may occur on the project trails at these seven trailhead locations. The availability of groomed trails facilitates cross-country skiing, snowshoeing, and other non-motorized recreation in locations where it might not otherwise occur.

2.7 OSV PROGRAM GROWTH LEVELS

2.7.1 Growth in OSV Program Operations

The OHMVR Division proposes funding the OSV Program for a 10-year period from 2010/2011 to 2019/2020. EIR Section 2.4 describes the typical grooming, plowing, and maintenance operations associated with the existing program that would continue forward over the next 10 years. No new trail systems are proposed to be added to the OSV Program at this point in time. However, it is conceivable that during the 10-year project horizon, the OSV Program could be expanded to include additional trail systems and trailheads. It is also possible the OSV Program operations at existing trail sites could be expanded by increasing the groomed trail mileage or by increasing the frequency of trail grooming. Either of these scenarios would directly result in increased hours of equipment operation. New plowing is proposed in one location, as described below, to improve winter access to an existing trail system.

<u>Expanded Trailhead Parking.</u> Additional parking at two existing trailheads is under consideration.

- The Four Trees trailhead is located on the southwest side of Bucks Lake in Plumas National Forest (Figure 6A). Vehicle access to this trailhead is from Oroville Quincy Highway. Four Trees was developed as a winter trailhead in 1991 although neither Oroville Quincy Highway nor the Four Trees parking area was ever plowed. Snow removal is planned on ten miles of Oroville Quincy Highway (County Road 414; Figure 6A) and at the Four Trees trailhead to provide western access to Bucks Lake and 20 additional parking spaces needed for the trail system visitors. This could generate an increase of 920 passenger vehicles and 1,840 OSVs per season (based on a 14-week season of 33 weekend/holidays and 65 weekdays and 2 OSV per passenger vehicle) on the Bucks Lake trail system or accommodate existing users from overcrowded parking at the Bucks Summit and Big Creek trailheads. Snow removal on the Oroville Quincy Highway would be performed by Butte County and/or its contractors. Based on snow depth levels expected on this stretch of road, and known plowing requirements for the Bucks Summit and Big Creek trailheads (Table 2-7), it is estimated that opening the Four Trees trailhead would require 500 hours of snow removal operations (plowing and/or blowing) per year.
- The China Wall trailhead is located on Foresthill Road in Tahoe National Forest (Figure 7C). The USFS is looking to expand the existing trailhead parking lot to provide 30 additional long spaces for vehicles pulling trailers. This would expand estimated parking capacity from 32 to 62 vehicles and could generate an increase of 1,380 passenger vehicles and 2,760 OSVs per season on the trail system based on a 14-week season. The parking lot would be closed during non-winter months due to lack of visitor demand. Environmental review for parking lot development is required under NEPA separate from the OSV Program. Environmental review of the parking lot development would be required under CEQA if state funded through the Grants Program. NEPA and if required, CEQA review, for this parking lot expansion is expected to commence this year with construction completed in two to three years. Placer County is under contract to Tahoe National Forest to plow three miles on Foresthill Road and the existing China Wall

trailhead parking lot and would plow the expanded parking area to maintain visitor access. Annual snow removal equipment operations for the existing road and parking area are 32 hours (Table 2-7). Thus the increase in snowplow or blower hours required to maintain the expanded portion of the China Wall parking area would be minimal.

Increased Grooming on Existing Trails. Presently, the OSV Program operates grooming equipment for roughly 5,000 hours annually (Table 2-2). Annual grooming hours fluctuate according to seasonal variations in snow volume and length of season. Over the 10-year program period, it is reasonable to expect that increased OSV use at the trail sites could result in demand for increased grooming frequency of existing groomed trails or new grooming of trail routes which are presently ungroomed. However, the grooming schedule is set by snowfall events and not by OSV use levels. Grooming operations at most trail systems currently operate near a maximum level. The OHMVR Division estimates that any increase in annual grooming equipment operation hours over the 10-year program period would not likely exceed 500 hours – roughly 10% of existing annual grooming operations. Equipment hours could also be reduced during the 10-year project period due to replacement of older equipment in the grooming vehicle fleet with newer, more powerful, and more efficient models. The replacement program for the OHMVR Division off-road vehicle fleet is further described in Section 2.4.1.

New Trail Systems. During the 10-year program period, the number of trail systems groomed by the OSV Program could be expanded to include new trail locations. No new trail sites are currently proposed for future inclusion in the OSV Program. However, given present day demands for OSV recreation and the popularity of some ungroomed locations, OHMVR Division staff has identified several locations that could be considered for State funding under the OSV Program within the next 10 years. These sites include:

- Lake Davis (Plumas National Forest). Lake Davis is located in Plumas County north of Portola off State Route 70 (Figure 13, Lake Davis). The trailhead parking lot was developed in 1989. This recreation area has existing parking for 25 vehicles with a single vault restroom located of Lake Davis Road. Plumas County currently plows approximately 10 miles of access road from Portola to Lake Davis. Based on parking capacity, potential OSV use of the groomed trail system from this trailhead is estimated at 2,300 OSV per season based on a 14 week season. There is general interest by Plumas National Forest in establishing 20 miles of groomed trail to be maintained by contract groomers. Grooming would occur on an existing road system which is seasonally closed. There are no immediate plans to create a new groomed trail system at Lake Davis as part of the OSV Program and no future groomed trail routes have been determined.
- State Route 4 – Carson Ranger District (Humboldt-Toiyabe National Forest). A new trailhead and groomed trail may be established on the Humboldt-Toiyabe National Forest to connect to the Lake Alpine trail system on the Stanislaus National Forest (Figure 14, State Route 4). Although there are no immediate plans available, the possibility of establishing a new trailhead and groomed trail is being discussed between OHMVR Division and the USFS. The new trailhead would be located near the State Route 4/State Route 89 junction below Monitor Pass and would consist of parking for 30 vehicles and a double vault restroom. Based on parking capacity, potential OSV use of the groomed trail system from this trailhead is estimated at 2,760 OSV per season. The new grooming would occur on approximately 30 miles of State Route 4 (seasonally closed) between Bear Valley and the State Route 4/State Route 89 junction. Grooming would be provided by a contract groomer. New plowing on roughly 6 miles of State Route 89 from Markleeville south to the new trailhead would be provided by Alpine county.

- Bass Lake (Sierra National Forest). Bass Lake is located in Madera County east of the State Route 49/State Route 41 junction (Figure 15, Bass Lake). There is no existing trailhead parking or restrooms at this location. Eight miles of plowed county road access on Beasore Road is provided by Madera County. Road side parking for winter recreation occurs on Beasore Road. There is general interest by Sierra National Forest in establishing 18 miles of groomed trail to be maintained by contract groomers. Grooming would occur on an existing road system which is seasonally closed. Assuming roadside parking capacity is 10 vehicles, potential OSV use of the groomed trail system is estimated at 920 OSV per season. There are no immediate plans to create a new groomed trail system at Bass Lake as part of the OSV Program and no future groomed trail routes have been determined.

The three trail systems combined would add 68 miles of groomed trail and 3 plowed trailheads to the OSV Program. This total grooming mileage represents the average size of one existing trail system (1,761 miles of trail over 26 trail systems). The addition of Lake Davis, State Route 4, and Bass Lake trail systems to the OSV Program would likely require up to 600 hours of grooming equipment operation per year based on average operations as shown in Table 2-2 (5,000 grooming hours over 26 trail systems). This level of activity would provide 20 days operation at 10 hours per day at each trail system. Plowed access to Lake Davis and Bass Lake is already provided by county road departments; therefore new plowing associated with future groomed trail systems at these two locations would be minimal. New plowing would be required to open a new trailhead on State Route 4 at Monitor Pass. Based on average snow removal operations as shown in Table 2-7 (2100 hours over 14 trailheads), the addition of this trailhead to the OSV Program would require 150 hours per year of snow removal equipment operation. This level of activity would provide 18 days of snow removal operation at 8 hours per day.

As discussed in Introduction (Section 1.2), site specific impacts of developing new State-funded groomed trail sites where the use does not already exist would be subject to environmental review under CEQA as a separate project. OSV Program maintenance of the three potential new trails identified above is covered by this EIR.

Thus, based on the potential described above, for increased operations at existing trail sites as well as the expansion to new locations, the maximum growth in OSV Program operations during the next 10 years (2010 to 2020) is defined by the EIR as increasing annual grooming equipment operations by 1,100 hours and snow removal operations by 700 hours. This takes into account the planned new plowing on Oroville Quincy Highway to open the Four Trees trailhead and plowing on the expanded China Wall trailhead, the flexibility of increasing grooming operations at existing sites (identified in Section 2.3 above) as needed to meet user or weather demands, and the potential to expand grooming and plowing operations at new locations not currently funded by the OSV Program.

2.7.2 Growth in Winter Trail Recreation

In 1982, the OHMVR Division began funding its first groomed trail system in the Sierra National Forest (Tamarck). Nine more trail systems were added in the mid to late 1980’s and 15 more trail systems were added between 1990 and 1992. The last trail system, Jonesville in Lassen National Forest, was added to the groomed trail system in 1996. The groomed trail system funded by the OHMVR Division has since remained static. The following section describes the growth trends in winter recreation and the change in visitor use levels which can be expected at the project sites during the proposed 10-year program funding.

2.7.2.1 OSV Recreation

According to a CDPR snowmobile user survey, approximately 14,000 snowmobiles were registered in the State of California in July 1997 (CDPR 1998). A survey was sent to every tenth registered snowmobile owner (800 out of 8,000 families) to inquire about trailheads visited and the level of visitor satisfaction. The return rate from the 800 surveys was 44%. The results indicated that the most often used staging areas were located in Eldorado National Forest (Hope Valley Sno-park, Iron Mountain), Tahoe National Forest (Little Truckee Summit, Bassetts) and Plumas National Forest (Bucks Lake, La Porte). However not all OSV Program trailheads were listed as options in the survey. The survey did not include the Inyo National Forest snowmobile area of Mammoth Lakes/June Lake or Sequoia National Forest trailheads of Sugarloaf, Eastside, Greenhorn Summit, and Quaking Aspen. For the majority of survey respondents there were four or more people in their typical snowmobile group (72%), and the number of miles traveled by snowmobile on a typical day was less than 80 miles (87%). These results are consistent with the findings of the 2009 Winter Trailhead Survey presented in Appendix A.

The California Department of Motor Vehicles (DMV) identifies 22,499 snowmobiles actively registered in California as of April 30, 2009 (Appendix B). An additional 392 snowmobiles are registered to out-of-state owners. Total Year 2009 registrations are an increase of approximately 8,900 over the 14,000 registrations in 1997, representing a 4.2% average annual increase. 2009 OSV registrations with DMV are down slightly from a peak level of 23,202 in 2008. Although snowmobile sales have weakened with the recession, it is reasonable to expect that OSV use will continue to increase at a similar average rate over the next 10 years resulting in additional snowmobile use of groomed trails and open riding areas as well as increased visitor parking at trailheads. The EIR assessment of project effects over the 10-year program period reflects a 4% average annual increase in project supported OSV use. Based on this growth rate, seasonal OSV use in the Project Area could increase 48%[1] from 159,000 (Table 2-8) to 235,000 by Year 2020. This corresponds to roughly 117,000 vehicles and 300,000 visitors per year at the trailhead parking areas assuming two OSVs per parked vehicle and vehicle occupancy of two to three persons.

2.7.2.2 Non-motorized Recreation

General snow play and non-motorized recreational use of groomed trails (e.g., cross-country skiing and snowshoeing) is likely to continue at similar levels in the Project Area over the 10-year planning horizon for the project. An indicator of non-motorized recreation use levels is the number of sno-park permits purchased for use of the 19 sno-parks operated by CDPR throughout the state. The number of sno-park day permits sold has declined significantly since 2005 while the number of sold season permits has remained fairly constant over the eight years that CDPR has collected data (Table 2-10).

Over the 10-year life of the project planning period, it is assumed that non-motorized recreation at the seven sno-parks which provide trailhead parking for OSV Program trail systems will remain steady. Given the downward trend in day permit purchases, projecting an increase in non-motorized recreation use levels at sno-parks over the next ten years of the OSV Program project is tenuous. For the purposes of the EIR, it is assumed that the number of non-motorized users at the seven sno-parks which share parking with OSV Program trail systems as well as the number

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[1] 4% average annual increase over 10 years = 1.04 multiplied 10 times or $(1.04)^{10} = 1.48$ which is a 48% increase

of non-motorized users which may visit other OSV Program trail systems will remain similar to current use levels with no substantial increase.

Table 2-10. California Sno-Park Permits

Season	Season Permits Sold	Day Permits Sold
2001/2002	5,214	43,997
2002/2003	4,700	44,771
2003/2004	5,530	43,534
2004/2005	5,852	43,447
2005/2006	4,667	42,381
2006/2007	4,376	24,252
2007/2008	4,811	28,921
2008/2009	4,485	25,679

Source: CDPR 2009

2.8 MITIGATING MEASURES INCORPORATED INTO THE PROJECT

2.8.1 USFS Resource Management

OHMVR Division has incorporated the following measures into the OSV Program. These measures are implemented by the USFS as an ongoing part of the OSV Program operation.

Resource Monitoring. Each national forest monitors its trail systems for evidence of OSV trespass into closed areas, OSV use near or damage of sensitive plant and wildlife sites, and low snow areas subject to erosion concerns. Field inspection results are recorded on a Monitoring Checklist shown in Appendix C. Based on the results of monitoring, corrective actions can be taken as needed to address observed problems. Each national forest would continue to submit checklists annually to the OHMVR Division for review at the close of each winter season.

Management Actions. The national forests have identified special-status species known to occur or potentially occurring in OSV use areas during the winter season. Each national forest has Management Actions which address special-status wildlife species and habitat protection in the Project Area. These Management Actions serve to minimize potential effects of OSV use on these special-status species. The Management Actions include continued forest monitoring of the plant and wildlife species of concern and limiting the operating period on groomed trails within ¼ mile of known den sites or Protected Activity Centers. The specific Management Action for each species further described in Biological Resources (Section 5.2.7).

2.8.2 Vehicle Fleet Replacement or Upgrade

Both trail grooming and snow removal equipment used in the OSV Program are subject to state regulations requiring replacement or upgrade/retrofit to reduce air pollutant emissions. Compliance with regulations would cumulatively reduce the average OSV Program vehicle emissions and would more than offset increases in overall activity that may result from foreseeable program growth as described in Section 2.7.

2.8.3 Water Quality Management Practices

Snow removal operations conducted by the USFS, county road departments, or their contractors as part of the OSV Program (Table 2-6) are subject to federal (if on USFS lands) or state regulations governing water quality. Best Management Practices are implemented at the federal, state, and local level for compliance with by the federal Clean Water Act (CWA) and state Basin Plans as described in Section 6.1.

2.9 OSV PROGRAM ADMINISTRATION

2.9.1 OSV Program Funding

OSV Program activities are funded by the OHV Trust Fund and dispersed through one of two funding mechanisms. Annual funding of OSV Program operation and maintenance activities primarily occurs through the 2002 BCP which secured OSV Program funding from the OHV Trust Fund. The BCP allows for up to $1,000,000 to support grooming, plowing, and facility maintenance operations. The total amount encumbered each year varies somewhat based on anticipated fuel and labor costs and length of the snow season. The OSV Program has consistently provided roughly $900,000 annually over the past six years (2004 through 2010). Provided funds which have not been spent at the end of the contract period revert back to the OHV Trust Fund. Currently, 11 national forests and three county agencies as shown in Table 2-11 receive funding through the BCP for grooming, plowing, and facility maintenance services described above in Section 2.4.

The second funding mechanism for OSV Program related activity is the Grants Program. Whereas the BCP strictly funds grooming, plowing, and facility maintenance activities, the Grants Program funds can be used to fund supplemental OSV activities not allowed under the BCP such as purchase and maintenance of equipment and administrative support services described in Section 2.4.4. Historically, the Grants Program has not funded OSV Program related activities since the BCP was established. However, in 2010, five national forests were granted one-time funds totaling $227,445 for equipment purchases and supplemental staffing for cleaning maintenance, visitor contacts, and/or resource monitoring as shown in Table 2-11.

Typical funding levels expected over the 10-year program period may increase reflective of program growth levels described in Section 2.7 above. Such increases would be subject to availability of OHV Trust Funds. The OHV Trust Fund has a fluctuating revenue source (OHV registration fees, gas tax, and State Vehicular Recreation Area fees) and supports other OHV-related programs in addition to the OSV Program.

Table 2-11. OSV Program Funding, BCP Contract Years 2004 through 2010 and Grants Program Year 2010

	BCP Funding				Grants Funding
Funding Recipient	2-Yr Contract 2004-2006	2-Yr Contract 2006-2008	1-Yr Contract 2008-2009	1-yr Contract 2009-2010	1-yr Grant 2010
Klamath NF	94,000	134,000	58,500	58,500	
Modoc NF	34,776	40,000	21,500	21,500	
Shasta-Trinity NF	39,982	69,200	39,600	39,600	

Table 2-11. OSV Program Funding, BCP Contract Years 2004 through 2010 and Grants Program Year 2010					
	BCP Funding				Grants Funding
Funding Recipient	**2-Yr Contract 2004-2006**	**2-Yr Contract 2006-2008**	**1-Yr Contract 2008-2009**	**1-yr Contract 2009-2010**	**1-yr Grant 2010**
Lassen NF	190,886	155,000	84,500	84,500	
Butte County	220,590	100,000	60,000	60,000	
Sierra County	80,000	220,000	118,500	118,500	
Plumas County	129,382	130,000	105,250	105,250	
Plumas NF	132,250	142,000	49,000	49,000	51,500
Tahoe NF	76,000	112,000	65,500	65,500	46,500
Eldorado NF	81,560	80,000	30,000	30,000	
Humboldt-Toiyabe NF	0	0	0	0	105,000
Stanislaus NF	213,000	194,000	120,500	120,500	6,650
Inyo NF	72,200	74,000	42,000	42,000	
Sierra NF	140,000	127,000	76,062	76,062	
Sequoia NF	283,234	202,200	106,100	106,100	17,795
Totals	**1,787,860**	**1,779,400**	**977,012**	**977,012**	**227,445**

Source: CDPR, OHVMR Division 2009

2.9.2 OSV Program Administration

Under the proposed 10-year program period, the OHMVR Division would issue multi-year contracts to each participating agency.

Prior to annual release of OSV Program funds, each recipient must submit to the OHMVR Division the following data from the prior season: 1) Summary log of equipment hours for the season, 2) Monitoring checklist forms completed for all trails, 3) Summary log of patrol hours on trails and any enforcement actions taken, 4) Vehicle count at trailheads on weekend patrol days, 5) Summary of OSV trespass incidents and management actions taken or planned, 6) Demonstration of compliance with any OSV Program mitigation measures identified in this EIR. County recipients of OSV Program funds are responsible only for plowing or grooming and would report only on equipment hours since national forests conduct the resource monitoring and enforcement patrols.

OHMVR Division would review all end of the season reports submitted by the OSV Program CSA and contract recipients to determine whether all required resource monitoring and patrols have occurred and that recipients are in compliance with OSV Program requirements. Based upon this review, the OHMVR Division would make an administrative finding as to whether each recipient is in compliance with the OSV Program requirements and whether contracts would be issued for the following winter season. If during the course of its review, OHMVR Division determines that a recipient is not in compliance with the OSV Program requirements, the OHMVR Division would make an administrative finding of non-compliance and would not renew the contract with that agency until compliance can be demonstrated.

3.0 LAND USE PLANS AND POLICIES

The following discussion presents the land use plans and policies governing the winter recreational trail system in the national forests affected by the proposed OSV Program. This section addresses project consistency with federal land use policy as set forth by the Land Resource Management Plans of each national forest as well as consistency with the Wilderness Act, which protects wilderness areas adjoining many of the winter trail systems. Consistency with other applicable plans, such as air quality management plans, is discussed in relevant EIR chapters. All project activities occur on forest land with the exception of snow removal on county roads and the Chester-Lake Almanor trailhead, which is also on county land (Plumas County). Land use activities within the national forests are not subject to county general plan land use policies.

3.1 REGULATORY SETTING

3.1.1 Land Resource Management Plans

Each of the 11 national forests participating in the OSV Program have LRMPs which set forth Standards and Guidelines (S&Gs) relevant to OSV management. The S&Gs are divided into two types: forest-wide S&Gs (Appendix D, Table 1) and management prescriptions and management area S&Gs (Appendix D, Table 2). Forest-wide S&Gs apply to the entire national forest, whereas management prescriptions and management area S&Gs are narrower in scope applying only to specific resources, activities, or areas within the forest. The OSV Program groomed trail system and riding areas can extend across several different management areas within a single national forest.

There are seven national forests (Klamath, Modoc, Shasta-Trinity, Lassen, Plumas, Tahoe, and Inyo) that divide the forest geographically into management areas. These national forests have management area S&Gs in addition to the forest-wide S&Gs and management prescriptions (Appendix D, Table 2). Management area S&Gs define specific management actions within a management area.

Forest-wide S&Gs and management prescriptions relevant to OSV management can be generally combined into eight natural resource policy categories: Air Quality, Biology, Cultural Resources, Recreation, Resource Management, Timber, Watershed Management, and Wilderness. Many of the LRMPs are 20 or more years old and do not distinguish between OSVs and the all encompassing term OHV.

3.1.1.1 Forest-wide S&Gs

Below is a summary description of the eight policy areas addressed by forest-wide S&Gs which are relevant to OSV use and the OSV Program. Table 3-1 shows which LRMP policy areas identified by each national forest apply to the OSV Program project sites. A full listing of all forest-wide S&Gs relevant to the OSV Program is presented in Appendix D, Table 1.

Table 3-1. Overview of LRMP Forest-Wide Standards and Guidelines Relevant to OSV Program Trail Systems

National Forest	Trail System	S&G Categories
Klamath	Deer Mountain, Four Corners Medicine Lake	1,2,3,4,5,7
Modoc	Doorknob	1,2,3,4,5,7
Shasta Trinity	Pilgrim Creek	1,2,4,5,7,8
Lassen	Ashpan, Bogard, Fredonyer, Swain Mountain, Morgan Summit, Jonesville	1,2,4,5
Plumas	Bucks Lake, La Porte, Gold Lake	2,4,5,7
Tahoe	Bassetts, Little Truckee Summit, China Wall	2,4,7
Eldorado	Silver Bear	2,4,5,7
Stanislaus	Lake Alpine, Spicer Reservoir, Highway 108	1,2,4,7
Inyo	Mammoth Lakes Area	2,4,5,6,7
Sierra	Huntington Lake/Kaiser Pass, Tamarack Ridge	2,3,4,5,7
Sequoia	Big Meadow/Quail Flat, Quaking Aspen/ Sugarloaf, Kern Plateau	2,4,5,7

Key:
1 Air Quality; 2 Biology; 3 Cultural Resources; 4 Recreation; 5 Resource Management;
6 Timber; 7 Watershed Management; 8 Wilderness

Source: TRA Environmental Sciences, Inc. 2010

Air Quality

Air quality forest-wide S&Gs for each national forest require compliance with federal, state, and local air quality statutes and regulations for all projects. These include the Federal Clean Air Act and California Air Resources Board (CARB), and Air Pollution Control District (APCD) regulations. Each national forest identifies, maintains an inventory of, and monitors air quality related values (AQRV), which are air pollutants resulting from forest management activities. AQRV include but are not limited to road dust, wood smoke, and vehicle emissions (Appendix D, Table 1).

Biology

Biology related forest-wide S&Gs encompass fish, wildlife, plants, their habitats, and overall biodiversity management. The intent of these S&Gs is to ensure that biodiversity is managed sustainably such that viable populations of sensitive species and protection of their habitats are maintained in each national forest. Biodiversity S&Gs also address impacts to more common species such as black-tailed deer (*Odocoileus hemionus columbianus*). For example, all national forests have a guideline that protects the winter range of black-tailed deer. For federally-listed threatened and endangered wildlife and plants and their habitats, national forests are required to conduct a biological assessment of new activities on project sites to determine the presence or absence of species and sensitive habitats. These assessments are to be carried out in coordination with U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Game (CDFG) (Appendix D, Table 1).

Cultural Resources

Cultural resources forest-wide S&Gs state that all national forests must comply with the National Historic Preservation Act of 1978, the American Indian Religious Freedom Act of 1978, the National Environmental Protection Act (NEPA), as well as the Archaeological Resources Protection Act of 1979. The cultural resources S&Gs protect access to sites and locations important to traditional Native American religious and cultural practices. The cultural resources S&Gs also protect cultural resources by directing activities and use away from sensitive areas (Appendix D, Table 1). Mitigation plans are required for projects where impacts are unavoidable. A forest-wide inventory of cultural resources is maintained by each national forest.

Recreation

Every national forest maintains Recreation Opportunity Spectrum (ROS) guidelines and a motor vehicle use map (MVUM) to manage motorized recreation. The ROS guidelines divide each national forest into six classes: primitive, semi-primitive non-motorized, semi-primitive motorized, roaded natural, rural, and modern-urban. Motorized travel is prohibited in the primitive and semi-primitive non-motorized ROS classes. OSV trails are identified for users on the MVUM of each respective national forest. In national forests over-the-snow cross-country travel is open except where it is prohibited by law (Appendix D, Table 1). This means that OSVs are able to travel off of designated routes in national forests and into open riding areas which permit motorized use. In national monuments such as the Giant Sequoia National Monument, OSV use is restricted to designated roads.

Resource Management

The resource management forest-wide S&Gs address natural resources including water, riparian, geology, range, wild and scenic rivers, and law enforcement. The S&Gs state that projects are to follow NEPA and Forest Service Manual processes which include identifying best management practices (BMPs) during project-level environmental analysis. Also, all national forests shall utilize the Water Improvement Needs (WIN) inventory to maintain a watershed level list of water quality impacts and restoration needs. Riparian areas are to be given primary management emphasis to protect riparian habitat and sensitive species. Riparian management areas are to extend 100 feet horizontally from the edge of perennial streams, lakes, and reservoirs. Existing trails and roads are considered for rerouting outside riparian areas where necessary to eliminate or reduce unacceptable deterioration of riparian dependent resources. Management plans are to be developed for each established research natural area, special interest area, and for each existing wild, scenic and recreation river (Appendix D, Table 1).

Timber

The timber forest-wide S&Gs are written to limit potential resource conflict. Access to timber roads is open for designated nordic and snowmobile trails. Timber management policies do not apply to OSV use but do defer to recreation policies which delineate use of timber access roads for designated OSV trails.

Watershed Management

Watershed management S&Gs focus on conducting analyses before project implementation to limit impacts to watersheds. National forests are to cooperate with local, state, and federal agencies in long-range watershed planning. Each national forest conducts a WIN inventory to assess and prioritize water problems. Each national forest also applies cumulative watershed effects (CWE) methodology to assess the potential cumulative effects of each project. As well, all national forests are to designate OSV trails and open areas to minimize conflicts with sensitive watershed areas (Appendix D, Table 1).

Wilderness

Wilderness S&Gs focus on minimizing potential trespass into wilderness areas. Wilderness areas are closed by federal law to motorized vehicles (see Section 3.1.3 below). Encroachment signs are to be posted next to trails and areas open to OSV uses that are adjacent to wilderness areas (Appendix D, Table 1).

3.1.1.2 Management Prescriptions

Below is a description of the four natural resource policy areas addressed by the management prescriptions which are relevant to OSV use and the OSV Program. A full listing of management prescriptions is presented in Appendix D, Table 2.

Biology

Biodiversity management prescriptions range from broad landscape-level guidelines in which projects are to be subjected to interdisciplinary analysis before their implementation to species-specific actions within a given management unit. For example, in the Klamath LRMP, the special habitat prescription states that project activities shall be evaluated by a local interdisciplinary team, and appropriate guidelines for the project shall be written and documented (Appendix D, Table 2). Within a management area, each LRMP describes management actions for specific species. For example MA 14-2 of the Klamath LRMP states that seasonal restrictions may apply to activities that interfere with fawning, herd movement, or behavior (Appendix D, Table 2). Following this pattern, the biodiversity management prescriptions are structured so that each national forest can follow specific actions to limit the impacts to biodiversity.

Recreation

Recreation management prescriptions designate the locations where OHV use, including OSVs, is restricted, open, or closed. Every LRMP states that it will follow the ROS guidelines for each management area. The ROS guidelines list the types of recreation activities allowed. For example, if the management area is listed as ROS primitive then it is closed to OHV use. If the management area is listed as ROS roaded natural then it is open to OHV use. All LRMPs have ROS guidelines listed in the management direction section, and all management areas are given an ROS designation. Within each national forest specific management actions are outlined within some management areas. For example, Lassen LRMP lists specific OHV guidelines in eight of the thirty-eight management areas of the Project. Also, the Inyo LRMP limits OSV use in each prescription area based on the Winter Motor Vehicle Use Map (Appendix D, Table 2). In this manner, each national forest places specific restrictions on OSV use to limit its impacts.

Resource Management

Resource Management prescriptions are focused on limiting impacts to soil, water, range, and visual resources. The Modoc National Forest LRMP is the only plan that discusses soils and

OHV use. This LRMP states that in the Medicine management area, all OHV use will be restricted to roads and trails in sensitive soil areas (Appendix D, Table 2). Water prescriptions are outlined in three LRMPs: Inyo, Klamath, and Lassen. These LRMPs state that the national forests will support state water quality control requirements and local ordinances to mitigate adverse impacts from runoff onto national forest lands. Specifically, in Inyo National Forest at the Mammoth Escarpment management area, the national forest will work with responsible agencies to assure compliance with the water management plan for Mammoth Lakes Basin (Appendix D, Table 2).

Visual Resource prescriptions are found in Klamath and Modoc LRMPs. MA11-8 of the Klamath LRMP states that the national forest is to manage recreational settings to generally achieve semi-primitive and rural ROS conditions. In Modoc National Forest areas within the visual retention prescription are open to OHV use if impacts cannot be seen from primary roads.

Watershed Management

Watershed Management prescriptions state that national forests are to manage at the watershed scale by utilizing BMPs that follow regional water quality control board standards. Within some management areas the national forests work with agencies to ensure implementation of water management plans. For example, in Inyo National Forest, in the Mammoth Escarpment management area, the national forest works with agencies to assure compliance with the provisions of the Mammoth Lakes Basin water management plan. In some national forests watershed management actions are in place for the protection of endangered species. In the Upper Owens River management area, also in Inyo National Forest, riparian areas are managed to maintain high quality habitat for fish. In Klamath National Forest wilderness area watersheds are not altered or manipulated. Projects that take place near important water features are evaluated on a project by project basis. In the Bucks management area of Plumas National Forest, each project in the watershed is evaluated for its potential to degrade Bucks Lake water quality (Appendix D, Table 2).

3.1.2 Sierra Nevada Framework

The Sierra Nevada Framework applies to nine of the eleven national forests in the Project Area receiving OSV Program funding. The two forests not covered by the Framework are Klamath and Shasta-Trinity. The Record of Decision (ROD) for the Sierra Nevada Forest Plan Amendment Project was signed on January 12, 2001. This decision added a number of S&Gs to the Forest LRMPs. These include the establishment of Limited Operating Periods (LOPs) around sensitive species' reproductive sites if ongoing activities are shown to be causing unacceptable impacts. Several new analysis requirements have also been added to address the spread of noxious weeds in general and cumulative watershed effects for activities occurring within Riparian Conservation Areas (USFS 2001).

Specifically, OSV management is addressed in the forest-wide S&G R09 for roads (FEIS Volume 4, Appendix D1-25, Preferred Alternative Standards and Guidelines; USFS 2001). This S&G states that "Unless otherwise restricted by current forest plans or other specific area S&Gs, cross-country travel by over-snow vehicles would continue. Each national forest will designate its own access policies where off road travel is permitted." Thus, each national forest is to design policies with regard to over-snow vehicle access within their respective forests.

In 2004, the USFS amended the Sierra Nevada Framework. This decision was appealed and on May 14, 2008, the U.S. Court of Appeals placed an injunction on the amendment and remanded the decision back to the District Court. On August 1, 2008, the Eastern District Court of California issued its order on the 2004 Framework. The District Court found in favor of the government on all claims except one: failure to consider reasonable alternatives to the 2004 Framework as required by NEPA. On November 4, 2009, the District Court issued a remedy order that allows the USFS to continue implementing the 2004 Framework while it addresses the following court ordered remedies:

- Detailed consideration of a noncommercial funding alternative for fuels reduction projects planned in the future.
- Develop a supplemental EIS (SEIS) to the 2004 Framework to address the range of alternatives issue, to be completed by May 1, 2010.

On April 2, 2010, the plaintiff motioned the U.S. Court of Appeals for an injunction pending the conclusion of an appeal. The court granted the motion and preparation of the SEIS is on hold until the appeal process is concluded.

The Sierra Nevada Framework does not add any new policies governing OSV use and therefore is not further addressed in this land use plans and policies section.

3.1.3 Wilderness Act

The United States was the first country in the world to define and designate wilderness areas through law. The Wilderness Act of 1964 (16 U.S.C. 1131-1136, Public Law 88-577) permanently protected some of the most natural and undisturbed places in the U.S. The Wilderness Act continues to be the guiding piece of legislation for all wilderness areas. The Act describes wilderness as follows:

> "...lands designated for preservation and protection in their natural condition..." Section 2(a)
>
> "...an area where the earth and its community of life are untrammeled by man..." Section 2(c)
>
> "...an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvement or human habitation..." Section 2(c)
>
> "...generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable..." Section 2(c)
>
> "...has outstanding opportunities for solitude or a primitive and unconfined type of recreation..." Section 2(c)
>
> "...shall be devoted to the public purposes of recreation, scenic, scientific, educational, conservation and historic use." Section 4(b)

The wilderness designation is a protective overlay Congress applies to selected portions of federal lands administered by National Park Service, USFS, USFWS, and Bureau of Land Management.

The Wilderness Act created the National Wilderness Preservation System (NWPS), the system that collectively unites all individual wilderness areas. California has 148 wilderness units, with the second largest wilderness complex (contiguous wilderness acreage) in the contiguous United States found in the southern Sierra Nevada consisting of the southern half of the Yosemite Wilderness and the Ansel Adams, Dinkey Lakes, John Muir, Monarch, Sequoia-Kings Canyon, Golden Trout, and South Sierra Wildernesses (2,241,439 acres). Wilderness areas near the Project Area are identified in Table 3-2.

Hiking, camping, hunting, fishing, picnicking, kayaking and canoeing, swimming, backpacking, horseback riding, rafting, skiing, snow-shoeing, bird-watching, and many other forms of recreation are allowed in wilderness areas. Any form of non-mechanized use is generally permitted, and motorized travel is allowed in cases of emergencies. The Wilderness Act prohibits logging, road-building, and vehicle use, including both motor vehicles (such as snowmobiles, OHVs, and dirt bikes) and other mechanical vehicles.

3.2 Environmental Setting

All land in the Project Area occurs in national forests located throughout the mountainous regions of California (Map 1). Land uses within national forests are varied supporting recreation, lodging, tourism, and commercial industry related to natural resources contained within the forests such as timber harvesting, mineral resources, fishing, etc. The size of each national forest and the recreation opportunity for OSV use is described in Recreation, Table 8-2. Land uses in the national forests are governed by forest plans or Land Resource Management Plans which are described above in Section 3.1.1.

Lands adjoining the Project Area are typically undeveloped forest land available for recreational use. Wilderness areas, national parks and monuments, and state wildlife refuges are some of the special interest areas located in the project region (see Figures 16 through 36). The geographic and cultural areas of interest located nearest the project trail sites are shown in Table 3-2. Parcels of non-forest owned land are dispersed throughout the national forests many of which may be developed with rural residences.

Table 3-2. Special Interest Areas in Project Area Vicinity

National Forest	OSV Trail System	Wilderness, Geographic, and Cultural Special Interest Areas
Klamath	Deer Mountain	Mount Shasta Wilderness
Klamath	Four Corners Medicine Lake	Lava Beds National Monument, Medicine Lake, Pumice Stone Well, Deep Ice Caves, Glass Mt. Glass Flow, Medicine Lake Glass Flow, Burnt Lava Flow
Modoc	Doorknob	Lava Beds National Monument, Medicine Lake, Pumice Stone Well, Deep Ice Caves, Glass Mt. Geological Area
Shasta-Trinity	Pilgrim Creek	Mount Shasta Wilderness, Medicine Lake, Pumice Stone Well, Deep Ice Caves, Glass Mt. Geological Area
Lassen	Ashpan	Thousand Lakes Wilderness, Latour Demonstration State Forest, Lassen Volcanic National Park
Lassen	Bogard	Caribou Wilderness, Lassen Volcanic National Park, Eagle Lake
Lassen	Fredonyer	Mountain Meadows Reservoir

Table 3-2. Special Interest Areas in Project Area Vicinity

National Forest	OSV Trail System	Wilderness, Geographic, and Cultural Special Interest Areas
Lassen	Swain Mountain	Caribou Wilderness, Lassen Volcanic National Park, Lake Almanor, Swain Mountain Experimental Forest
Lassen	Morgan Summit	Lassen Volcanic National Park
Lassen	Jonesville	Coon Hollow Wildlife Area
Plumas	Bucks Lake	Bucks Lake, Bucks Lake Wilderness, Pacific Crest Trail
Plumas	La Porte	Pacific Crest Trail
Plumas	Gold Lake	Lakes Basin, Plumas Eureka State Park
Tahoe	Bassetts	Lakes Basin, Yuba River
Tahoe	Little Truckee Summit	Weber Lake, Independence Lake, Little Truckee River
Tahoe	China Wall	Granite Chief Wilderness, French Meadows Game Refuge, Placer Big Trees
Eldorado	Silver Bear	Mokelumne Wilderness
Stanislaus	Lake Alpine	Mokelumne Wilderness, Carson Iceberg Wilderness
Stanislaus	Spicer Reservoir	Carson Iceberg Wilderness
Stanislaus	Highway 108	Carson Iceberg Wilderness, Emigrant Wilderness
Inyo	Mammoth Lakes	Ansel Adams Wilderness, Summit Research Area, Crater Flats, Inyo Craters, Mono Craters Hot Springs Geological Area, Sentinel Meadow Research Natural Area, Devil’s Postpile National Monument, June Mountain and Mammoth Mountain Ski Areas, Mono Basin National Forest Scenic Area
Sierra	Huntington Lake, Tamarack Ridge	Kaiser Wilderness, Dinkey Lakes Wilderness, Ansel Adams Wilderness, John Muir Wilderness
Sequoia	Big Meadow/Quail Flat	Jennie Lakes Wilderness, Monarch Wilderness, Kings Canyon National Park, Sequoia National Park, Giant Sequoia National Monument, General Grant Grove, Converse Basin Grove, Big Stump Grove
Sequoia	Quaking Aspen/ Sugarloaf	Golden Trout Wilderness, Giant Sequoia National Monument, Tule River Indian Reservation
Sequoia	Kern Plateau	Kern River

Source: TRA Environmental Sciences, Inc. 2010

3.3 PROJECT IMPACTS

3.3.1 Thresholds of Significance

According to the CEQA Guidelines (Appendix G), a project will have a significant effect on land use if the following conditions occur:

- Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect; or
- Conflict with any applicable habitat conservation plan or natural community conservation plan.

The potential effects of OSV trespass into protected wilderness, other areas closed to OHV use, or private property are also evaluated in this EIR section. The following criteria were used to evaluate this impact:

- How frequently does the trespass occur?
- What was the nature of the trespass, purposeful or inadvertent?
- How deep into the wilderness area does trespass generally occur?
- What is the perceived magnitude of the problem by USFS staff?
- What is the current level of law enforcement?
- Would additional measures significantly reduce the impact?
- Has the trespass resulted in damage to private or public property, natural resources, or public safety impacts?

3.3.2 Project Baseline, Year 2010

3.3.2.1 Conformance with Land Use Plans and Policies

Direct OSV Program activities of plowing, trail grooming, and facility maintenance and indirect subsequent activity of OSV use of the project sites were evaluated for consistency with USFS LRMP policies. There are no habitat conservation plans or natural community conservation plans relative to the Project Area. OSV Program activity and OSV use of the winter trail systems have been occurring in national forests for decades.

Project conformance with each of the eight forest-wide S&Gs and management prescription policy categories is addressed below.

Air Quality

Snow Removal and Trail Grooming. Direct emissions from project equipment operations are consistent with federal and state air quality requirements (see Air Quality, Section 4.3.2.1). Direct project emissions conform to national forest LRMP air quality S&Gs requiring compliance with federal, state, and local air quality standards.

Passenger Vehicle Travel and OSV Use. Indirect emissions from visitor travel to the Project Area and OSV use of the groomed project trails are consistent with federal and state air quality requirements (see Air Quality, Section 4.3.2.1). Direct project emissions thus conform to national forest LRMP air quality S&Gs (Appendix D, Table 1) requiring compliance with federal, state, and local air quality standards.

Biology

Snow Removal and Trail Grooming. Plants and wildlife are not adversely affected by project activities of snow removal, which occurs on paved surfaces or trail grooming, which occurs on a minimum snow depth of 12 inches. Snow removal and trail grooming activities do not conflict with national forest LRMP S&Gs and management prescriptions governing the protection of biological resources within the forests (Appendix D, Tables 1 and 2). See Biology, Section 5.3.2 for further discussion.

Passenger Vehicle Travel. Passenger vehicle travel to the Project Area occurs on established paved roads. No biological effects occur from this activity, which is thus consistent with LRMP biological S&Gs and management prescriptions.

OSV Use. OSV use in the national forests facilitated by the OSV Program groomed trails occurs in areas consistent with LRMP designations for motorized recreation. This OSV use does not conflict with LRMP S&Gs or management prescriptions governing protection of biodiversity or specific biological resources in management areas. OSV use does not modify habitat. The USFS manages OSV use in areas where federal, state, or forest sensitive species could be adversely affected by monitoring resource locations and implementing limited operating periods or route closures consistent with LRMP S&Gs. The impact of OSV use on specific biological resources is addressed in Biology, Section 5.3.2. Inventories of CRPR and FSS listed species in the national forests near the OSV Program trails are incomplete as discussed in Biology, Section 5.3.2.2. If OSV use facilitated by the OSV Program trails is shown to be significantly damaging CRPR or FSS populations, the OSV Program would not be in conformance with forest-wide LRMP biodiversity S&Gs in several national forests which require maintenance of viable populations of native plant species or sensitive plant species (Appendix D, Table 1). Implementation of Measure BIO-4 in Biology, Section 5.4 would ensure OSV Program compliance with LRMP biodiversity S&Gs regarding special-status plant species.

Cultural Resources

Snow Removal and Trail Grooming. Project plowing and grooming activities occur on a network of established roads and trails that does not contain cultural resources. LRMP forest-wide and management area S&Gs governing cultural resources are not affected.

Passenger Vehicle Travel. Passenger vehicle travel to the Project Area occurs on established paved roads. No effects to cultural resources occur from this activity.

OSV Use. No ground disturbance occurs from OSV use where there is adequate snow cover. In low snow areas, OSV use could contact bare soil resulting in minor ground disturbance. Soil compaction associated with OSV use is minimal (Hydrology and Water Quality, Section 6.3.20). OSV use occurs on groomed trails where no cultural resources occur and in off-trail riding areas known to contain cultural resources such as Modoc National Forest; however, no cultural resources have been adversely affected by OSV use (see CEQA Issues, Section 10.0). Therefore, the Project is consistent with cultural resources LRMP S&Gs and management prescriptions governing the protection of cultural resources.

Recreation

Snow Removal, Trail Grooming, Passenger Vehicle Travel, and OSV Use. All groomed trails and riding areas within the Project Area occur in areas of the national forests with suitably designated ROS classes allowing OSV use and vehicle travel. The designated trail system and OSV use is therefore consistent with LRMP S&Gs and management prescriptions governing recreation.

Resource Management

Snow Removal, Trail Grooming, and Passenger Vehicle Travel. The use of snowplows and snowcats on established roads and trails and the travel of passenger vehicles on access roads do not affect soils, riparian resources, range management, or wild and scenic rivers which are addressed by LRMP S&Gs and management prescriptions governing resource management. These activities are therefore consistent with the LRMP.

OSV Use. Off-trail riding by OSVs could potentially affect soils under low snow conditions, although the potential effects of soil compaction and erosion are not considered significant (Hydrology and Water Quality, Section 6.3.2). Vegetation trampling and potential impacts to riparian resources from OSV use are also considered less than significant (Biology, Section 5.3.2). Wild and Scenic rivers cannot be accessed from the groomed trail system or adjoining riding area. Therefore, the Project is consistent with LRMP S&Gs and management prescriptions governing resource management.

Timber

Snow Removal, Trail Grooming, Passenger Vehicle Travel, and OSV Use. None of the direct (snow removal and trail grooming) or indirect (vehicle travel and OSV use) OSV Program activities affect timber stands. LRMP forest-wide timber S&Gs allow motorized OHV use of timber roads where it does not conflict with use of or access to timber stands. Therefore, the Project is consistent with these LRMP timber S&Gs and management prescriptions.

Watershed Management

Snow Removal, Trail Grooming, and Passenger Vehicle Travel. The direct project activities of snow removal and trail grooming and subsequent indirect activity of visitor travel to the Project Area occur over an existing road network and do not alter landforms or result in significant soil disturbance that would change water flow patterns or quantities of surface water runoff. Snow removal and passenger vehicle travel occur on paved surfaces. All trail grooming occurs over existing paved or dirt roads on minimum snow depth of 12 inches. Trail grooming does not cause substantial impacts to water quality, perennial, intermittent or ephemeral streams, wetlands or other bodies of water. Therefore, project activities of snow removal, trail grooming, and vehicle travel are consistent with LRMP watershed management S&Gs and management prescriptions.

OSV Use. The majority of OSV use occurs on groomed trails where there is adequate snow cover and low potential for contact with bare soil. OSV use on the groomed trail system does not cause substantial impacts to water quality, perennial, intermittent or ephemeral streams, wetlands or other bodies of water. In open riding areas, OSV use can contact bare soil under low conditions or encounter water resources. As described in Hydrology and Water Quality, Section 6.3.2 the Project does not result in significant soil erosion and therefore does not create water quality impacts to streams or water bodies by introducing sediment in water runoff. Exhaust emissions on the snow pack from grooming equipment or OSV are considered minor and do not impair water quality of snow melt (Hydrology and Water Quality, Section 6.3.3). Therefore, the indirect project activity of OSV use is consistent with LRMP watershed management S&Gs and management prescriptions.

Wilderness

Snow Removal and Passenger Vehicle Travel. Snow removal occurs on existing paved roads and provides passenger vehicle access to trailheads and snow play areas. Providing plowed access on an existing road network does not impact protected wilderness areas.

Trail Grooming and OSV Use. LRMP ROS designations prohibit motorized use within wilderness areas in conformance with the Wilderness Act. Several of the winter trail systems in the Project Area are located adjacent to wilderness areas in national forests. As described below in Section 3.3.2.2, the groomed trails indirectly facilitate OSV access to the wilderness boundaries and wilderness incursions in some locations. USFS relies on law enforcement patrols, citations, signage, and public outreach to enforce the wilderness boundaries within the national forests. With continuation of management levels currently employed by the USFS (Section 3.3.2.2), the 2010 OSV use levels facilitated by project activities of snow removal and trail grooming do not significantly affect wilderness areas and does not conflict with LRMP protection of wilderness areas.

3.3.2.2 OSV Intrusion into Closed Areas

Wilderness Areas

The USFS patrols wilderness areas near OSV Program groomed trails to enforce the wilderness boundaries that are closed to OSV use. Wilderness boundaries near OSV areas are signed to identify the boundary and prohibit trespass. USFS uses law enforcement officers and forest protection officers to patrol project trail sites and known areas of concern on skis, snowmobiles, and by fixed-wing airplane. OSV trespass into closed areas can result in citation.

As shown in Table 3-2, sixteen wilderness areas in addition to national parks and monuments are located in the vicinity of the Project Area. USFS has identified nine wilderness areas as known hot spots or problem areas for OSV intrusion that require USFS monitoring as shown in Table 3-3. Two of the known trespass locations, Mount Shasta Wilderness (Shasta-Trinity National Forest) and Mokelumne Wilderness near the Blue Lakes area (Eldorado National Forest), are accessed from areas not associated with the OSV Program trails or trailheads. These trespasses are therefore not considered impacts caused by the OSV Program.

Intrusion by OSV users originating within the Project Area occurs in the following wilderness areas: Mount Shasta Wilderness (Klamath National Forest), Lassen Volcanic National Park and Caribou Wilderness (Lassen National Forest), Bucks Lake Wilderness (Plumas National Forest), Mokelumne Wilderness along Squaw Ridge (Eldorado National Forest), Kaiser Wilderness (Sierra National Forest) and John Muir Wilderness (Sierra National Forest), Carson-Iceberg Wilderness (Stanislaus National Forest), Mokelumne Wilderness between Hope Valley and Lake Alpine (Stanislaus National Forest), Golden Trout Wilderness (Sequoia National Forest), and South Sierra Wilderness (Sequoia National Forest) (see Table 3-3). The characteristics of these intrusions are described below.

<u>Klamath National Forest.</u> Intrusion into the Mount Shasta Wilderness area occurs near Brewer Creek on the East side of Shasta Mountain. OSV users entering this area likely originate from the Deer Creek trailhead. Although trespass in this area has historically been a problem, increased patrols and better signage have reduced the frequency of intrusion in recent years.

<u>Lassen National Forest.</u> Two trespass issues originate in the Lassen National Forest: Lassen Volcanic National Park near Eskimo Hill and Caribou Wilderness near Echo Lake and Cone Lake. Trespass into Lassen Volcanic National Park likely originates from Ashpan or Morgan Summit trailhead, while trespass into Caribou Wilderness likely begins at the Swain Mountain trailhead. Intrusion into Lassen Volcanic National Park is not known to be a chronic problem by USFS or National Park staff. Intrusion into Caribou Wilderness area is believed to occur due to poor signage and no distinct geographic feature that delineates the wilderness area boundary. However, this problem is not considered to be chronic by USFS staff.

Plumas National Forest. Trespass into Bucks Lake Wilderness area from Plumas National Forest Service groomed trails occurs near the trailhead of the Bucks Summit Staging area. The wilderness area boundary comes close to that of the trailhead in an area with an attractive slope for snowmobilers. Riders will ride up the slope, cross into wilderness territory, and then ride back down into national forest lands. More aggressive signage and patrols in recent years have reduced the frequency of occurrence.

Eldorado National Forest. Originating from the Eldorado National Forest, trespass into the Mokelumne Wilderness area occurs in the area of Squaw Ridge. Trespassers must leave the groomed trail system and then travel 0.25 miles to enter the wilderness area. Users trespassing into this area are likely entering the system at the Iron Mountain trailhead. Trespass in this area is not considered chronic.

Sierra National Forest. Trespass into the Kaiser and John Muir Wilderness areas originate from the Kaiser and Huntington Lake trailheads in Sierra National Forest. Although additional signage and law enforcement personnel would likely help alleviate trespass pressure, the situation was not deemed significant given the perceived low intensity of trespass.

Stanislaus National Forest. Trespass into Carson Iceberg Wilderness area near Highlands Lake at Folger Peak Bowl and Hiram Peak Bowl originates from the Alpine Lakes trailhead in Stanislaus National Forest. Trespass occurs because of the attractiveness and proximity of the bowls to the groomed trail system. Increased OSV patrol of wilderness boundaries and signage in recent years has reduced the frequency of trespass, although several citations are still given every year. In 2009, three wilderness trespass citations were issued at Hiram Peak Bowl during aerial patrol.

Trespass into the Mokelumne Wilderness area also originates at the Alpine Lakes trailhead in Stanislaus National Forest. Users use Mokelumne Wilderness lands to travel between Stanislaus and Eldorado National Forest. On the Eldorado National Forest side, users enter the Mokelumne Wilderness from the Hope Valley area, which is a groomed system under private operation. Despite frequent land and air patrols and the existence of an official corridor between these two national forests on Mokelumne Wilderness lands, trespass still occurs. Although the frequency of this trespass issue is somewhat high, the significance of this impact was determined to be less than significant as current law enforcement efforts are perceived by USFS staff to be commensurate with the level of impact.

Sequoia National Forest. Trespass into the Golden Trout Wilderness area near the north end of Monache Meadows and into the South Sierra Wilderness area near the south end of Monache Meadows originates from the Sequoia National Forest Kern Plateau-eastside trailhead. Trespass into these wilderness areas is purposeful, requiring users to travel several miles off of the groomed trail system, sometimes requiring fuel caches. This trespass issue was determined to be less than significant due to the infrequency of the offense and the relatively light use of the trail system in general.

Given the proximity of several groomed trail systems to wilderness boundaries, some OSV trespass from the Project Area into protected wilderness would occur from the Project at the current baseline conditions (Table 3-3). Unintentional intrusion would continue to be addressed by increased signage, public outreach, and law enforcement patrols. Wilful trespass could occur regardless of these measures. Fencing and increased patrols can be helpful in blocking access and deterring repeat offenses by catching violators and issuing citations. Those national forests reporting trespass incidents indicate that wilderness intrusion is not a chronic condition and that they have implemented measures as needed to minimize the occurrence. Based on interviews with USFS staff about the nature, probable origin, frequency, magnitude, and perceived severity of the problem (significance criteria identified in Section 3.3.1), in conjunction with ongoing USFS patrols, enforcement, and education, none of the trespass issues are considered significant from a qualitative standpoint. Because addressing trespass is a high priority for the OHMVR Division, however, Mitigation Measure LU-1 would ensure the USFS and OHMVR Division continue to work cooperatively to ensure trespass into closed areas is immediately identified and addressed and remains less than significant. The likelihood of increased OSV intrusion over the 10-year program period is addressed below in Section 3.3.3.

Table 3-3. OSV Intrusion Areas, 2009

National Forest	OSV Intrusion Area	Origin of OSV	Patrol Type/ Frequency
Klamath	Mount Shasta Wilderness near Brewer Creek on East side of Shasta Mountain	Deer Mountain trailhead and Pilgrim Creek trailhead	2 patrols/wk 30 person days
Klamath	Private properties	undetermined	
Modoc	Private property with cabins near Medicine Lake	Shared trail system with Shasta-Trinity, Klamath, and Modoc	Seldom patrolled
Shasta-Trinity	Mount Shasta Wilderness on south side of Mt. Shasta. Private subdivision near Pilgrim Creek trailhead off State Route 89	Bunny Flat trailhead (outside Project Area) Pilgrim Creek trailhead	n/a
Lassen	Lassen Volcanic National Park near Eskimo Hill	Ashpan or Morgan Summit	LEO weekends FPO weekdays
Lassen	Caribou Wilderness near Echo Lake and Cone Lake	Swain Mountain	
Plumas	Bucks Lake Wilderness near Bucks Summit Staging area	Bucks Summit trailhead	5 patrols/wk
Eldorado	Mokelumne Wilderness along Squaw Ridge	Iron Mountain trailhead	Weekend patrols 28 person days
Eldorado, Humboldt-Toiyabe	Mokelumne Wilderness near the Blue Lakes area	Groomed trails accessed from the Hope Valley Sno-Park (outside Project Area)	Aerial patrol, 97 person days patrol in the Hope Valley
Stanislaus	Carson Iceberg Wilderness near Highlands Lake at Folger Peak Bowl and Hiram Peak Bowl	Lake Alpine	Aerial patrols and weekend patrols
Eldorado, Stanislaus	Mokelumne Wilderness between Hope Valley and Lake Alpine trail	Lake Alpine	Aerial patrols and weekend patrols
Inyo	North Zone: Crater Flats, Minaret Vista, Mammoth Lakes Basin, Glass Flow Nordic area (administrative closure areas). South Zone: Bishop Creek, Ancient Bristlecone Pine Forest, Golden Trout Wilderness and South Sierra Wilderness near Monache Meadows.	North Zone: Mammoth Lake groomed trails South Zone (outside of Project Area)	LEO 5 patrols/wk FPO 2 patrols/wk

Sierra	Kaiser and John Muir Wildernesses where these areas border the trail system	Kaiser and Huntington Lake trailheads	Patrols on holiday and heavy-use weekends
Sequoia	Giant Sequoia National Monument near Sand Pit and Buck Rock Lookout	Big Meadow/Quail Flat trailheads	Weekend patrols
Sequoia	Giant Sequoia National Monument near Ponderosa	Private residential properties	Limited patrols
Sequoia	Golden Trout Wilderness near north end of Monache Meadows	Kern Plateau-Eastside trailhead	Limited patrols
Sequoia	South Sierra Wilderness near south end of Monache Meadows	Kern Plateau-Eastside trailhead	

Notes:
LEO – Law Enforcement Officer
FPO – Forest Protection Officer
Tahoe National Forest did not report wilderness intrusion.
Sequoia National Forest reports OSV intrusion as rare or not an issue.

Source: USFS 2009

Private Property and other Administrative Closure Areas

Private property trespass by OSV use has been reported by Modoc and Shasta-Trinity National Forests (Table 3-3). The trespass issue on Modoc National Forest was not deemed significant by USFS staff due to its infrequency. The trespass issue on subdivision property reported by Shasta-Trinity National Forest near Pilgrim Creek was unable to be confirmed or acted upon by USFS staff given that the incident was reported after the close of the riding season.

Administrative OSV Closure Areas include Nordic ski areas which occur in numerous locations throughout the national forests, high visitor use areas such as those in Inyo National Forest near Mammoth Lake, and the Giant Sequoia National Monument. Trespass into these areas is generally resolved by patrol and public outreach to educate OSV users on closed area boundaries. Occasional user conflicts between OSV and cross-country skiers have been reported in the Giant Sequoia National Monument near the community of Ponderosa as well as OSV use off designated routes. Sequoia National Forest has received state funding through the Grants Program for the 2010/2011 season to provide increased patrols to address these issues. Previous incidents mitigated by visitor education with the information boards, handouts, and initiating contact. For the 2009/2010 winter season, information boards, handouts, and regular patrols were conducted to educate and enforce Forest rules and regulations. Signage (Carsonite posts) were installed in the Sand Pit area to educate visitors on remaining on designated routes when in the Forest.

The Klamath National Forest reports that there is a considerable amount of private land that interfaces with National Forest lands along the snowmobile corridor trails. The “Becket & Becket Tree Farm Trail Agreement” and permission from Sierra Pacific Industries authorizes snowmobiles to cross the tree farm land on a designated trail to reach public land. The agreement does not authorize random riding on Tree Farm property. The “Hart & Louie Ranch Meadow Areas” strictly prohibits snowmobile use on their lands. The larger Timber Companies (Sierra Pacific Industries, Fruit Growers Supply Company. and TP) lands are aware of snowmobile use on their lands. Violators who ride on the private land closed to snowmobiles are warned and repeat violators referred to the private landowner for a trespass complaint.

Given the proximity of several groomed trail systems to private property and Administrative OSV Closure Areas, some OSV trespass into these areas would occur from the Project at current baseline conditions (Table 3-3). Unintentional intrusion would continue to be addressed by increased signage, public outreach, and law enforcement patrols. Wilful trespass could occur regardless of these measures. Fencing and increased patrols can be helpful in blocking access and deterring repeat offenses by catching violators and issuing citations. Those national forests reporting trespass incidents indicate that intrusion is not a chronic condition and that they have implemented focused enforcement actions as needed to minimize the occurrence. Based on interviews with USFS staff about the nature, probable origin, frequency, magnitude, and perceived severity of the problem (significance criteria identified in Section 3.3.1), in conjunction with ongoing USFS patrols, enforcement, and education, no significant impacts have been identified. In the absence of ongoing enforcement efforts, trespass incidents could increase and, if patrols and law enforcements were not implemented the trespass issues could result in a significant impact.

The OHMVR Division and USFS have successfully partnered in the past to implement focused enforcement actions such as aerial patrols and public education to successfully address specific trespass concerns that arise. Measure LU-1 requires that USFS continue monitoring wilderness boundaries, private property, and other closed areas near the OSV Program trails and that the OHMVR Division work with USFS and County Sheriff Offices to implement focused enforcement efforts to address increased OSV trespass incidents as warranted. Implementation of Measure LU-1 would reduce the potential for increased trespass into areas closed to OSV recreation to a less-than-significant level.

Because addressing trespass is a high priority for the OHMVR Division, however, and unchecked trespass could quickly rise to a level of significance, Mitigation Measure LU-1 would ensure the USFS and OHMVR Division continue to work cooperatively to ensure trespass onto private land and closed areas is immediately identified and addressed and remains less than significant. The likelihood of increased OSV intrusion over the 10-year program period is addressed below in Section 3.3.3.

3.3.3 10-Year Program Growth, Year 2020

3.3.3.1 Conformance with Land Use Plans and Policies

Air Quality

Expanded Trailhead Parking. Expanded trailhead parking at Four Trees and China Wall would result in an additional 500 hours of new snow removal equipment operation per year and subsequent increase in use of the trailheads by 2,300 passenger vehicles or 4,600 OSV riders per season. The Four Trees trailhead already exists and the China Wall trailhead exists but would be enlarged for increased capacity. Use of these trailheads would support continued recreational use of established winter trails and does not conflict with LRMP S&Gs regarding compliance with federal, state, and local air quality regulations.

Increased Grooming at Existing Trails. Increased grooming operations at existing trails would add 1,100 hours of snowcat operations to the OSV Program by Year 2020 to accommodate growth in OSV recreation. Emissions from the increased grooming are described in Air Quality, Energy, and Greenhouse Gases, Sections 4.3.2 and 4.3.4. This increase conforms with LRMP S&Gs which require compliance with federal, state and local air quality standards.

New Trail Systems. New trail systems would add new direct project emissions from operation of snow removal and grooming equipment as indirect emissions from passenger vehicle travel to the new trail sites. The three new trails with the potential to be added to the OSV Program by 2020 (Project Description, Section 2.7.1) would require roughly 600 hours of grooming and 150 hours of plowing and would support 2,990 parked vehicles and 5,980 OSV riders. The air quality emissions from the new trail systems are included in the assessment of OSV Program growth operations for Year 2020 in Air Quality, Energy, and Greenhouse Gases, Sections 4.3.2 and 4.3.4. This increase conforms with LRMP S&Gs which require compliance with federal, state and local air quality standards.

Growth in OSV Recreation. As the demand for winter recreation grows, it is inevitable that fuel consumption from project equipment operation (snow removal and trail grooming), OSV use, and passenger vehicle travel would increase resulting in an increase in NOx, ROG, and GHG emissions. Project emissions are described in Air Quality, Energy, and Greenhouse Gases, Sections 4.3.2 and 4.3.4. This increase conforms with LRMP S&Gs which require compliance with federal, state and local air quality standards (see Appendix D, Table 1).

Biology

Expanded Trailhead Parking. Snow removal on the Oroville Quincy Highway and Four Trees trailhead (Plumas National Forest) and on an expanded China Wall trailhead (Tahoe National Forest) which would occur under the OSV Program growth would occur on paved surfaces and would not adversely affect biological resources. Snow removal to expand trailhead parking would not conflict with LRMP S&Gs or management prescriptions governing biological resources. Development of the trailhead expansion at China Wall is subject to NEPA review and would be designed and constructed in conformance with applicable USFS S&Gs.

Increased Grooming at Existing Trails. Increased grooming operations at the 26 existing trail sites do not create new biological impacts or introduce new conflicts with USFS management of biological resources. Increased grooming under the 10-year program growth would be consistent with LRMP S&G and management prescriptions governing biological resources.

New Trail Systems. The biological effects of establishing a new trail system or new OSV use in national forests would be subject to new environmental review under NEPA and would be planned, constructed and implemented consistent with LRMP S&Gs governing biological resources.

Growth in OSV Recreation. Increased OSV use in off-trail riding areas along the groomed trail system could result in increased impact to CRPR and FSS plant species which are potentially present but have not been inventoried and are not monitored by the USFS. As described in Section 3.3.2.1 above, implementation of Measure BIO-3 would bring the OSV Program into to conformance with LRMP S&Gs and management prescriptions governing biological resources.

Cultural Resources

Expanded Trailhead Parking. Snow removal on the Oroville Quincy Highway and Four Trees trailhead (Plumas National Forest) and on an expanded China Wall trailhead (Tahoe National Forest) which would occur under the OSV Program growth would occur on paved surfaces and not adversely affect cultural resources. Snow removal to expand trailhead parking would not conflict with LRMP S&Gs or management prescriptions governing cultural resources.

Development of the trailhead expansion at China Wall is subject to NEPA review and would be designed and constructed in conformance with applicable USFS S&Gs.

Increased Grooming at Existing Trails. OSV Program activities in the Project Area do not impact cultural resources and are consistent with LRMP S&Gs and management prescriptions governing cultural resources. See Section 3.3.2.1 above. Increased plowing or trail grooming operations at the existing OSV Program trail locations would not create new impacts to cultural resources and therefore would be consistent with LRMP S&G and management prescriptions governing cultural resources.

New Trail Systems. Cultural resources, if present at the potential new trail grooming sites identified in Project Description, Section 2.7.1, would not likely be impacted given the protective snow cover and the absence of ground disturbance activity associated with the Project. Site specific impacts of new trail development would be subject to new environmental review under CEQA.

Growth in OSV Recreation. OSV recreation does not impact cultural resources at existing trail locations. See Section 3.3.2.1 above. Increased OSV use at the existing OSV Program trail locations would not create new impacts to cultural resources and therefore would be consistent with LRMP S&G and management prescriptions governing cultural resources.

Recreation

Expanded Trailhead Parking. Snow removal on the Oroville Quincy Highway and at Four Trees trailhead (Pumas National Forest) as well as at the expanded China Wall trailhead (Tahoe National Forest) would increase public access to the groomed trail system and facilitate winter recreation in areas of the national forest open to motorized use. Expansion of the OSV Program to include the Four Trees trailhead and add capacity to the China Wall trailhead is consistent with LRMP ROS designations governing recreational use on the Plumas and Tahoe National Forests.

Increased Grooming at Existing Trails. All plowed access roads, groomed trails and riding areas within the Project Area occur in areas of the national forests with suitably designated ROS classes allowing OSV use and vehicle travel. See Section 3.3.2.1 above. Increased plowing or trail grooming operations at the existing OSV Program trail locations would also be consistent with LRMP S&Gs and management prescriptions governing recreation.

New Trail Systems. Plowing, grooming, and OSV use at the three potential new groomed trail sites identified in Project Description, Section 2.7.1 would be evaluated by the USFS for consistency with LRMP ROS designations and S&Gs and management prescriptions governing recreational uses at the time these sites are actually proposed for development and incorporation into the OSV Program.

Growth in OSV Recreation. All groomed trails and riding areas within the Project Area occur in areas of national forests with suitably designated ROS classes allowing OSV use. Increased OSV use at existing OSV Program trail locations would also be consistent with LRMP S&Gs and management prescriptions governing recreation.

Resource Management

Expanded Trailhead Parking. Snow removal on the Oroville Quincy Highway and at Four Trees trailhead as well as at the expanded China Wall trailhead would occur on established roads parking areas. The use of snowplows and subsequent passenger vehicles on these access and parking facilities would not affect soils, riparian resources, range management, or wild and scenic rivers which are addressed by LRMP S&Gs and management prescriptions governing resource management. These activities are therefore consistent with the LRMP.

Increased Grooming at Existing Trails. Snow plowing and grooming occurs on an established road network and does not affect soils, riparian resources, range management, or wild and scenic rivers which are addressed by LRMP S&Gs and management prescriptions governing resource management. Increased plowing or trail grooming operations at the existing OSV Program trail locations would also be consistent with LRMP S&Gs and management prescriptions governing resource management.

New Trail Systems. Plowing and grooming at the new trail sites identified in Project Description, Section 2.7.1 would occur on an existing road or trail network and would therefore not affect soils, riparian resources, range management, or wild and scenic rivers which are addressed by LRMP S&Gs and management prescriptions governing resource management. OSV use at these new trail systems would be evaluated for site specific impacts on natural resources governed by LRMP S&Gs and management prescriptions at the time these sites are actually proposed for development and incorporation into the OSV Program.

Growth in OSV Recreation. Off-trail riding by OSVs could potentially affect soils under low snow conditions although the potential effects of soil compaction and erosion are not considered significant (Hydrology and Water Quality, Section 6.3.2). Vegetation trampling and potential impacts to riparian resources from OSV use are also considered less than significant (Biology, Section 5.3.2). Wild and scenic rivers cannot be accessed from the groomed trail system or adjoining riding area. Therefore, the Project is consistent with LRMP S&Gs and management prescriptions governing resource management.

Timber

Expanded Trailhead Parking. Snow removal on the Oroville Quincy Highway and at Four Trees trailhead as well as at the expanded China Wall trailhead does not affect timber resources and would not conflict with LRMP timber S&Gs and management prescriptions.

Increased Grooming at Existing Trails. Snow removal and trail grooming activities do not affect timber stands. LRMP forest-wide timber S&Gs allow motorized OHV use of timber roads where it does not conflict with use of or access to timber stands. Increased plowing or trail grooming operations at the existing OSV Program trail locations would also be consistent with LRMP S&Gs and management prescriptions governing timber.

New Trail Systems. Development of new trail systems as identified in Project Description, Section 2.7.1 would occur on an existing road network and would not require removal of timber stands. Subsequent OSV use of the new trails would also not affect timber resources. The new trail systems would be consistent with LRMP S&Gs and management prescriptions governing timber.

Growth in OSV Recreation. OSV use in the Project Area does not affect timber stands. LRMP forest-wide timber S&Gs allow motorized OHV use of timber roads where it does not conflict with use of or access to timber stands. Increased OSV use at the existing OSV Program trail locations would also be consistent with LRMP S&Gs and management prescriptions governing timber.

Watershed Management

Expanded Trailhead Parking. Snow removal occurs on paved surfaces and does not change water flow patterns or quantities of surface water runoff, affect water quality, or otherwise affect bodies of water (see Watershed Management discussion in Section 4.3.2.1 above). Snow removal on the Oroville Quincy Highway and Four Trees trailhead as well as at the expanded China Wall trailhead would not introduce new watershed impacts and would also be consistent with LRMP watershed management S&Gs and management prescriptions.

Increased Grooming at Existing Trails. Trail grooming occurs over an existing road network and does not alter landform or cause soil disturbance that would change water flow patterns or quantities of surface water runoff, affect water quality, or otherwise affect bodies of water (see Watershed Management discussion in Section 4.3.2.1 above). Increased plowing and grooming would not introduce new watershed impacts and would also be consistent with LRMP watershed management S&Gs and management prescriptions.

New Trail Systems. New trail systems would be developed over an existing road or OHV trail network and snow removal, trail grooming, and subsequent OSV use would not change the landform or disturb soils or vegetation which could affect water flow patterns or quantities of surface water runoff. Higher levels of vehicle exhaust from project equipment and OSV use would occur on the watershed snowpack due to introduction of new or increase mobile emissions. However the impact would not be significant (see Hydrology and Water Quality, Section 6.3.3). The impact of new trail systems on local watersheds and the consistency of the these new trail systems with LRMP watershed S&Gs and management prescriptions would be evaluated at the time the sites are actually proposed for development and incorporation into the OSV Program.

Growth in OSV Recreation. The majority of OSV use occurs on groomed trails where there is adequate snow cover and low potential for contact with bare soil. Likewise, the majority of increased OSV use would also occur on the groomed trail system where contact with perennial, intermittent or ephemeral streams, wetlands or other bodies of water would not occur. Increased OSV use in open riding areas would increase the potential for OSV contact with bare soil under low conditions or encounter water resources and increase exhaust emissions on the snow pack. As described in Hydrology and Water Quality, Section 6.3.3.1 the effects are not significant and therefore, increased OSV recreation does not conflict with LRMP watershed management S&Gs and management prescriptions.

Wilderness

Expanded Trailhead Parking. Plowing the Oroville Quincy Highway to open the Four Trees trailhead at Bucks Lake (Plumas National Forest) could alleviate overflow parking conditions at Bucks Summit (Table 8-3) and potentially reduce the number of wilderness intrusions occurring from that staging area (Table 3-3). The nearest wilderness to the China Wall trail system, Granite Chief Wilderness, has not been impacted by OSV use from China Wall. Expansion of the snow removal operation at the China Wall trailhead would not introduce a new impact to this wilderness. Opening the Four Trees trailhead for winter use and plowing an expanded trailhead at China Wall would not conflict with LRMP S&Gs governing protection of wilderness.

Increased Grooming at Existing Trails. Increased grooming needed to serve OSV use at the existing groomed trail systems would not conflict with LRMP S&Gs governing wilderness or exacerbate OSV trespass issues described above in Section 3.3.3.

New Trail Systems. The new trail systems that may potentially be established by the OSV Program during the next 10 years as identified in Project Description, Section 2.7.1 would not occur in protected wilderness areas. Indirect impacts to wilderness areas could occur from OSV trespass as described below in Section 3.3.3.2.

Growth in OSV Recreation. Increased OSV use at existing OSV Program trail locations could increase OSV trespass into wilderness areas. This is further discussed below in Section 3.3.3.2.

3.3.3.2 OSV Intrusion into Closed Areas and Private Property

Expanded Trailhead Parking. Snow removal on Oroville Quincy Highway and the Four Trees trailhead parking lot would not result in new exposure of the Bucks Lake Wilderness (Plumas National Forest) to OSV use and would not expand the groomed trail system at Bucks Lake. The Four Trees trailhead could relieve parking demand pressure at the Bucks Summit and Big Creek trailheads by providing access to Bucks Lake from the west side of the lake. To the degree that opening Four Trees reduces the OSV staging out of Bucks Summit, it is possible that unintentional wilderness trespass occurring at the Bucks Summit trailhead could be reduced.

Expanding the China Wall trailhead parking lot by 30 spaces could double the OSV use of the trail system (Project Description 2.7.1). Tahoe National Forest reports that there are currently no known OSV trespass problems at its trailheads. An increased in use at China Wall by 2,940 OSVs is unlikely to result in new OSV trespass issues.

Increased Grooming at Existing Trails. Increased plowing and grooming needed to serve OSV use at the existing 26 groomed trail systems would not conflict with LRMP S&Gs governing wilderness or exacerbate OSV trespass issues described above in Section 3.3.3.

New Trail Systems. Three new locations have been identified as possible sites for establishing new groomed trail systems. OSV use already occurs in the Lake Davis and Bass Lake areas on ungroomed trails. County road departments currently provide plowed access to these areas. Establishing a groomed trail system could attract increased OSV use at these two locations. Plowed access is not available at the State Route 4 Monitor Pass area so OSV use at this third location would be new.

Lake Davis is not located near wilderness areas so there is no potential for wilderness trespass from a future trail system at this location. State Route 4 between Lake Alpine and Monitor Pass threads between Mokelumne Wilderness and Carson Iceberg Wilderness. Both of these wildernesses receive trespass from OSV use originating from Lake Alpine (Table 3-3). Extending the groomed path along 30 miles of State Route 4 (Humboldt-Toiyabe National Forest) could increase the number of wilderness incursions in this area. At Bass Lake (Sierra National Forest), Beasore Road (County Road 7) approaches Ansel Adams Wilderness to the east. A groomed trail system established on Beasore Road could increase the amount of OSV use near the Ansel Adams Wilderness boundary and increase the potential for OSV incursion into this wilderness. New OSV incursion into wilderness would be a likely effect from establishing a Bass Lake and State Route 4 Monitor Pass trail system.

Based on the analysis presented in above, continued active monitoring, public education, and law enforcement efforts by USFS staff, as prescribed by Measure LU-1, would continue to be effective in preventing the occasional trespass from becoming a chronic condition.

Development and use of new groomed trail systems under the OSV Program would be subject to future environmental review and approval under NEPA for the USFS and CEQA for the OHMVR Division. Potential impacts to wilderness associated with the new trail systems would be evaluated at such time as the projects are actually proposed.

Growth in OSV Recreation. Based on historic trends, annual OSV use throughout the Project Area can be expected to increase from 159,000 to 235,000 by 2020 (Project Description, Section 2.7). As described in Section 3.3.3, OSV intrusion into closed areas including wilderness, private property, and Administrative OSV Closure Areas occurs on a limited basis. If a substantial increase in OSV use in the Project Area occurs over the next 10 years, it is reasonable to conclude that the incidents of OSV intrusion into closed areas may increase. Such increased trespass would be a significant impact. Improved signage, public outreach, and increased patrols of closed area boundaries may be necessary on trail systems where OSV incursion into wilderness becomes chronic. These USFS management actions have been effective in curbing wilderness intrusions, and more implementation of these same management tools would continue to prove effective in handling increased incursion incidents caused by growth in OSV use levels.

The OHMVR Division and USFS have successfully partnered in the past to implement focused enforcement actions such as aerial patrols and public education to successfully address specific trespass concerns that arise. Measure LU-1 requires that USFS continue monitoring wilderness boundaries, private property, and other closed areas near the OSV Program trails and that the OHMVR Division work with USFS and County Sheriff Offices to implement focused enforcement efforts to address increased OSV trespass incidents as warranted. Implementation of Measure LU-1 would reduce the potential for increased trespass into areas closed to OSV recreation to a less-than-significant level.

3.3.4 Cumulative Impacts

There are no known activities or projects occurring in the national forests which would overlap with the OSV Program activities resulting in a cumulative effect concerning land use issues. Incidents of OSV trespass into wilderness areas, administrative closure areas, and private property occur throughout the Project Area as described in Table 3-3 from non-OSV Program sites such as ungroomed trails and private residences. The USFS and County Sheriff’s Office provide law enforcement efforts at these locations. There are no other activities in the national forests which would contribute to OSV intrusion of wilderness areas or other areas closed to OSV use.

3.4 MITIGATION MEASURES

Implementation of the following measure would ensure OSV Program compliance with applicable USFS LRMP S&Gs and management prescriptions regarding special-status plant species and wilderness protection.

IMPACT: *If inventories and subsequent monitoring show that OSV use is damaging CRPR or FSS populations, the OSV Program would conflict with forest-wide LRMP biodiversity S&Gs in several national forests which require maintenance of viable populations of native plant species or sensitive plant species (Appendix D, Table 1).*

Measure BIO-4: (see Biology, Section 5.4)

Implementation:	By OHMVR Division and USFS
Effectiveness:	Completion of inventories and implementation of protective measures would minimize significant impacts on special-status plant species from OSV operations.
Feasibility:	Feasible
Monitoring:	USFS shall submit completed inventories to OHMVR Division for review. USFS shall maintain a log of monitoring efforts and any management actions implemented to protect sensitive status plants. This log shall be submitted to OHMVR Division for agency review each summer prior to contract approval for OSV Program operations for the following winter season.

Implementation of the following measure would ensure the potential impacts of trespass into wilderness, private property, and other closed areas remain less than significant.

IMPACT: *OSV trespass into wilderness areas facilitated by project groomed trails could occur under baseline use levels and would likely increase beyond present levels due to growth in OSV recreation over the 10-year program period. Current areas of trespass which may receive a higher incidence of intrusion from increased OSV use during the 10-year program period include: Mount Shasta Wilderness (Klamath National Forest), Lassen Volcanic National Park and Caribou Wilderness (Lassen National Forest), Bucks Lake Wilderness (Plumas National Forest), Mokelumne Wilderness along Squaw Ridge (Eldorado National Forest), Kaiser and John Muir Wilderness (Sierra National Forest), Carson-Iceberg Wilderness (Stanislaus National Forest), Mokelumne Wilderness between Hope Valley and Lake Alpine (Eldorado and Stanislaus National Forests), Golden Trout Wilderness (Sequoia National Forest), and South Sierra Wilderness (Sequoia National Forest).*

Measure LU-1: All national forests participating in the OSV Program shall monitor wilderness boundaries, private property, and other closed areas near the groomed trail system for OSV incursions. National forests shall submit patrol logs to Division showing hours and days of patrol in known trespass locations, number of observed trespass incidents, and number of citations issued. National forests shall identify to the OHMVR Division what management actions have been taken and what, if any, additional actions are needed to further prevent trespass into wilderness areas, private property, or other closed areas. OHMVR Division shall work with law enforcement personnel from the USFS and County Sheriff Offices to implement focused enforcement actions as needed to address trespass incidents such as increased patrol frequency, aerial patrols, public education, signage, fencing, or trail closure.

Implementation: By USFS and OHMVR Division

Effectiveness: Existing management actions have been effective at preventing wilderness trespass from becoming an escalating chronic condition. With continued management and implementation of focused enforcement actions, wilderness incursions would not be eliminated but would be minimized to a less than significant level.

Feasibility: Feasible; the USFS and OHMVR Division have implemented focused enforcement actions previously to resolve trespass issues.

Monitoring: National forests shall submit patrol logs and statement of needed management actions to OHMVR Division at end of each snow season and prior to OHMVR Division release of OSV Program funds to the national forests for the following winter season.

4.0 AIR QUALITY, ENERGY, AND GREENHOUSE GASES

The proposed continuation of the OSV Program would contribute funding to support maintenance of motorized winter recreation facilities. As described below, the program directly funds use of diesel-powered heavy equipment for plowing parking areas and grooming trails. Plowing and grooming equipment is a direct mobile air emissions source. This facility maintenance accommodates recreation use, so visitors' travel to and from the trailhead and OSV use on trails are indirect mobile air emissions sources. All of these mobile sources consume energy as petroleum based fuels and consequently emit carbon dioxide, which is a greenhouse gas associated with global climate change.

4.1 REGULATORY SETTING

4.1.1 Ambient Air Quality Standards

The Clean Air Act (CAA) establishes federal standards known as National Ambient Air Quality Standards (NAAQS). The CAA requires states to submit a State Implementation Plan for areas not in attainment with NAAQS. The CAA also sets forth provisions regarding mobile sources such as gasoline reformulation and tailpipe emissions standards and establishes the regulatory process for evaluating emissions from stationary sources – New Source Review (NSR) for non-attainment pollutants and Prevention of Significant Deterioration (PSD) for attainment pollutants. The California Clean Air Act (California CAA) establishes state standards known as the California Ambient Air Quality Standards (CAAQS). In general, the CAAQS are more stringent than the corresponding NAAQS.

In California, air quality is governed by the CARB. The State is geographically divided into 15 air basins defined by geographic features such as valleys and mountains. Air quality within these basins is managed by 35 different air districts, which are called Air Quality Management Districts (AQMD) or APCDs. These agencies are county or regional governing authorities that have primary responsibility for monitoring and enforcing state and federal air quality standards. Each air district sets its own regulations for air pollutant emissions in order to achieve compliance with federal and state ambient air quality standards. These thresholds are used by the air districts as a screening level to see if proposed emissions from stationary sources should be subject to further review such as NSR or PSD. The off-highway mobile sources of the proposed Project are not subject to air district NSR or PSD.

4.1.2 Air Pollutants

Particulate Matter. Particulate matter is small diameter solid particles or liquid droplets suspended in the air. Particulate matter may be produced by natural causes (e.g., pollen, ocean salt spray, soil erosion) and by human activity (e.g., road dust, agricultural operations, fuel combustion products, wood burning, rock crushing, cement production, and motor vehicles). Of greatest concern to public health are the particles small enough to be inhaled into the deepest parts of the lung. These particles are less than 10 microns in diameter – about 1/7th the thickness of a human hair – and are known as PM_{10}. Regulation is also now focusing on a class of smaller fine particulate matter known as $PM_{2.5}$ comprising particles less than 2.5 microns in diameter.

Exposure to particle pollution is linked to an increased frequency and severity of asthma attacks and bronchitis, and even premature death in people with existing cardiac or respiratory disease (NSVPA 2006). In addition to health impacts, these particles can reside in the atmosphere for long periods of time and are the main contributors to reduced visibility.

Diesel Particulate Matter (DPM). DPM is a carcinogen regulated as a Toxic Air Contaminant (TAC) separately from its contribution to PM_{10} and $PM_{2.5}$ pollution. Diesel exhaust contains carcinogenic polycyclic aromatic hydrocarbons, arsenic, benzene, and formaldehyde. The threshold of significance for TAC, including DPMs, is an elevation of lifetime cancer risk greater than 10 in one million (E+10-5).

Nitrogen Oxides (NOx). Nitrogen dioxide (NO_2), a toxic reddish-brown gas, and nitric oxide (NO), a colorless gas, comprise NOx. Because NOx is an ingredient in the formation of ozone, it is referred to as an ozone precursor. Both NO_2 and NO are produced as a result of fuel combustion. NO_2 is associated with adverse health effects such as breathing difficulties at high concentrations and is formed in the atmosphere when NO is oxidized to NO_2. NO_2 further oxidizes to form nitric acid when dissolved in atmospheric moisture, forming a component of acid rain and by further reaction to nitrate ion, which contributes to fine particulate (PM_{10}). NO_2 itself is a weak GHG but when returned to earth in the form of nitric acid, it is then reduced to nitrous oxide (N_2O) by soil bacteria. Nitrous oxide absorbs about 310 times as much energy (heat) than an equal weight of carbon dioxide (CO_2).

Carbon Monoxide (CO). CO is a colorless, odorless gas resulting from incomplete combustion of carbon-containing fuel. CO interferes with oxygen uptake by hemoglobin in the blood, and exposure even at low levels leads to headache, nausea, chest pain, and confusion. Prolonged exposure and exposure to higher levels can cause death.

Reactive Organic Gases (ROG). ROG are also termed hydrocarbons (HC) or volatile organic compounds (VOC). A broad class of organic gases can react with NOx in the presence of sunlight to create ozone, the principal chemical in smog. Except for a few toxic air contaminants like benzene, ROG are rarely of direct concern as air pollutants. They are regulated primarily for their potential to contribute to ozone formation.

Ozone. Ozone is a gas composed of three oxygen atoms. It is not usually emitted directly into the air, but at ground level is created by a chemical reaction between NOx and ROG in the presence of sunlight. Ozone is typically a seasonal problem, occurring from May through October when warm weather and more intense sunlight accelerate ozone formation. Sources for the pollutants that react to form ozone include motor vehicles, power plants, factories, chemical solvents, combustion products from various fuels, and consumer products. Health effects associated with ozone are related to the body’s respiratory system. When ozone levels are high, people with lung disease (e.g., chronic bronchitis, emphysema, and asthma) are particularly susceptible to adverse health impacts.

4.1.3 Mobile Source Regulation

Emissions from the diesel powered heavy equipment, used for project plowing and grooming activities, and recreational-related emissions from visitor travel and OSV use are subject to a combination of federal and state emissions regulations.

4.1.3.1 Off-Road Heavy-Duty Diesel Vehicles

The principal air pollutant emissions for diesel-fueled heavy equipment are NOx and PM; unlike gasoline engines, diesel produces low CO and ROG. CARB and the U.S. Environmental Protection Agency (EPA) have identified on- and off-road diesel as important contributors to regional NOx and particulate emissions with attendant ozone and health impacts, so a series of emissions reduction programs have been put in place involving engine redesign and use of low sulfur fuel. The EPA has established progressive emission standards for these sources to be implemented in a series of "tiers." For non-road diesel engines, Tier 2 standards apply for equipment manufactured between 2001 and 2006. Tier 3 standards apply for equipment manufactured between 2006 and 2008. The most stringent standards, Tier 4 standards, consist of an interim and final set of standards. The standards for engines less than 75 horsepower (hp) start in 2008, the standards for engines between 76 and 174 hp begin in 2012, and the standards for engines 175 hp and greater begin in 2011. California has adopted and accelerated the EPA emissions reduction program.

CARB's In-Use Off-Road Diesel Vehicles Regulation, adopted in 2007, aims to reduce emissions of NOx and PM from in-use off-road (i.e, non-road) diesel vehicles. The regulation imposes limits on engine idling and adding older (typically pre-1996) off-road diesel vehicles to fleets beginning in 2009, requires all vehicles to be reported to CARB and labeled in 2009; and then in 2010 begins gradual requirements for fleet clean up including getting rid of older engines, using newer engines, and installing exhaust retrofits. The regulation does not apply to recreational off-highway vehicles.

The following requirements are in effect and being enforced by CARB to regulate off-road heavy duty diesel vehicles:

- Buying Tier 0 Vehicles Prohibited – No fleet subject to the regulation may purchase a Tier 0 off-road diesel vehicle; Tier 0 vehicles are vehicles produced without an emission standard, generally before 1996.
- Idling Limited to 5 Minutes – Exceptions for vehicles that need to idle to perform work (such as a crane providing hydraulic power to the boom), or vehicles being serviced, or in a queue waiting for work. Medium and large fleets (those with over 2,500 horsepower of off-road diesel vehicles) must have a written idling policy.
- Selling Any Off-road Diesel Vehicle – The seller (whether a dealer or a contractor with just one vehicle) must provide disclosure of the regulation on the bill of sale or invoice, with the exact language provided in the regulation, and keep records for three years.
- Emissions and Performance Requirements –The regulation establishes a requirement that off-road fleets be progressively upgraded to meet overall fleet emissions limits. The rate of progress is based on fleet size, with state- and federally-owned fleets being automatically considered "large" and hence subject to the most rapid change. OHMVR Division maintains an electronic database of all its off-road equipment, which tracks the installation of newer or lower emissions equipment. All equipment upgrades to the vehicle fleet are logged into the database which is then submitted to CARB for regulatory oversight. CARB reviews the vehicle data submitted by OHMVR Division to ensure compliance with the fleet requirements.

In California, both on-road and off-road diesel fuel is required to have low sulfur content.

4.1.3.2 On-Road Heavy-Duty Diesel Vehicles

Snow removal equipment comprises plow blades and snow blowers mounted on heavy-duty on-road diesel trucks. As with off-road grooming equipment described above, the principal air pollutant emissions from snow removal equipment are NOx and PM. Air quality management of on-road heavy-duty diesel vehicles in California involves emissions reduction through engine redesign, use of low sulfur fuel, and retrofitting older vehicles to trap particulates. The reductions are to be implemented by fleet managers who can use various methods of meeting progressive fleet-wide emissions limitations. These upgrades are monitored by CARB to ensure compliance with vehicle fleet requirements.

The OHMVR Division does not directly own or operate the snow removal equipment used to clear project access roads and trailheads (Project Description, Section 2.4.2 and Table 2-6). The OSV Program supports snow removal operations by funding labor and fuel needed to operate the equipment. Snow removal equipment is owned and operated by the USFS, county agencies, or private contractors. The owner-operators of these vehicles report to CARB directly for compliance with fleet vehicle regulations; OHMVR Division is not responsible for the regulatory compliance of these vehicles. State-owned plow equipment used by Caltrans is not funded by the OSV Program but is funded by the Sno-Park Program.

4.1.3.3 Over-Snow Vehicles

OSVs are gasoline powered. Small gasoline engines are available in either a two-stroke or four-stroke design. In a four-stroke engine, as used in automobiles, a complete power cycle in each cylinder requires two complete revolutions of the crankshaft to complete four strokes: one to draw in air or an air-fuel mixture, one to compress it, one to ignite it and do work, and one to exhaust the cylinder. In a two-stroke engine a complete power cycle requires only one revolution of the crankshaft and only two movements of the piston with the beginning of the compression stroke and the end of the combustion stroke performing simultaneously the intake and exhaust functions. Two-stroke engines usually have oil added to fuel for lubrication whereas four-stroke engines have lubricant added separately to the crankcase.

Historically, two-stroke engines were favored for OSVs because of the high power for the engine weight, lighter engines, lower initial cost, unique features such as electronic reverse, and characteristic performance. Concern over air emissions and noise has led to introduction of four-stroke versions of major OSV designs, and four-stroke OSV sales have increased slowly. Based on user surveys, the OHMVR Division estimates that current users at OSV Program trail sites are approximately 4% four-stroke equipment and the remaining 96% are two-stroke designs (Project Description, Table 2-9).

The principal air pollutants of concern for OSVs are HC and NOx. Because of their manner of operation, pre-regulated (i.e., pre-2006 model year) two-stroke engines produce significantly more HC than four-stroke engines. Lela and White (2002) documented emissions differences, concluding “Commercially-available four-stroke snowmobiles are significantly cleaner than two-stroke sleds. Compared to previously tested two-strokes, these four-stroke sleds emit 98 to 95 percent less HC, 85 percent less CO, and 90 to 96 percent less PM. Four-stroke snowmobile NOx, however, is considerably higher than from a two-stroke, being increased by a factor of seven to twelve.” While this information is not current for newly manufactured vehicles, it remains relevant to pre-2006 vehicles which are part of the 2010 baseline fleet.

The EPA and CARB have begun to set emissions goals for recreational vehicles, including OSVs. The CARB approved the OHV regulations in 1994. That rulemaking established emission standards and test procedures for OHVs including off-highway motorcycles (dirt bikes) and all-terrain vehicles (ATVs). CARB is currently conducting further testing of recreational vehicles, including OSVs, in order to evaluate efficacy of further controls.

The EPA adopted new emissions standards in 2002 for snowmobiles and other recreational vehicles to reduce air pollution from hydrocarbon and carbon monoxide. Manufacturers were required to begin meeting these regulations in 2006, with the EPA emissions requirements becoming increasingly more stringent by 2012. The EPA's phased restrictions apply to a manufacturer's fleet and reduce HC and CO emissions by as much as 50% and 30%, respectively, plus an additional 15 percent HC/CO reduction combination. Court challenges have delayed publication of a final requirement for OSVs manufactured after 2012. In principle, the reduced emissions can be met by a combination of four-stroke engines and two-stroke engines with advanced features such as fuel injection.

With the uncertain future emissions restrictions, fleet mix, user acceptance, and rate of phase out of older equipment, it is difficult to predict what in-use OSV emissions will be over the next 10 years. As emissions controls take effect, the OSV user fleet at trail sites in the Project Area will show increased use of four-stroke engines or advanced two-stroke engines; it is likely that emissions will be reduced by roughly half of current rates by 2020.

4.1.3.4 On-Highway Motor Vehicles

On-highway motor vehicles, including automobiles and light trucks, are a major source of air emissions statewide and have been subject to a broad range of emissions reduction strategies at state and federal levels. Engine controls, exhaust treatment, and clean fuel requirements have significantly reduced emissions as measured in grams per mile, offsetting the increase in total miles traveled resulting from population increase.

On December 21, 2005, CARB requested a waiver on federal preemption of California's GHG emissions standards to allow California to enact emissions standards to reduce CO_2 and other GHG from automobiles. On June 30, 2009 the EPA granted this waiver. The California "Clean Car" standards require increased fuel efficiency, reducing GHG emissions from light and medium duty vehicles by an average of 30% (CARB 2005). By 2016, the fleet fuel efficiency standard for all passenger cars will be 39 mpg, and it will be 30 mpg for light trucks and sport utility vehicles. Current light-truck fuel economy standards are 23.1 mpg for all SUVs, pickups, vans, and crossovers.

The new regulations do not cover heavy-duty pickup trucks that fall in the 8,500-10,000 pound range, however, in May 2010 the EPA and the National Highway Traffic Safety Administration took the first steps to reduce GHG emissions from heavy-duty trucks ranging in size from large pickup trucks to combination tractor-trailers, or "18 wheelers" (EPA 2010).

4.1.4 Greenhouse Gas Regulation

The state has begun a series of legislative and regulatory approaches to dealing with global climate change in recognition of the fact that California is vulnerable to the effects of global climate change, and, that despite its global nature, action to curb GHG emissions is needed on a statewide level.

4.1.4.1 California Global Warming Solutions Act – AB32

The California Global Warming Solutions Act of 2006 (AB32) requires CARB to reduce GHG emissions to 1990 levels by 2020. CARB identified 427 million metric tons of carbon dioxide equivalent (MMTCO2e) as the total statewide GHG 1990 emissions level and adopted this level as the 2020 GHG emissions limit (CARB 2007a). CARB estimates 2020 GHG emission levels will reach approximately 600 MMTCO2e if no actions are taken under a "business-as-usual" scenario.

The 1990 California GHG inventory includes the following gases: CO_2, methane (CH_4), N_2O, sulfur hexafluoride (SF_6), hydrofluorocarbons (HFC), and perfluorocarbons (PFC). Each GHG has a different capacity to trap heat in the atmosphere by absorbing infrared radiation. Almost 90% of the total GHG identified in the inventory is CO_2 (CARB 2007a). The majority of 1990 emissions are tied to fuel use activities such as electrical generation, transportation, and industrial operations (CARB 2007a).

CARB approved the AB32 Climate Change Scoping Plan on December 11, 2008. Key elements of the plan include:

- Expanding and strengthening existing energy efficiency programs as well as building and appliance standards;
- Achieving a statewide renewables energy mix of 33 percent;
- Developing a California cap-and-trade program that links with other Western Climate Initiative partner programs to create a regional market system;
- Establishing targets for transportation-related greenhouse gas emissions for regions throughout California, and pursuing policies and incentives to achieve those targets;
- Adopting and implementing measures pursuant to existing State laws and policies, including California's clean car standards, goods movement measures, and the Low Carbon Fuel Standard; and
- Creating targeted fees, including a public goods charge on water use, fees on high global warming potential gases, and a fee to fund the administrative costs of the State's long term commitment to AB 32 implementation.

4.1.4.2 SB375

In SB375, California enacted several measures to reduce vehicular emissions through land-use planning. CARB will develop GHG emission reduction targets for the automobile and light truck sector for each metropolitan planning organization.

4.1.4.3 California Climate Adaptation Strategy

The California Climate Adaptation Strategy (Adaptation Strategy), developed pursuant to Executive Order S-13-2008, is a policy statement that contains recommendations on how the State can plan for the effects of climate change. This non-regulatory document encourages advanced planning to anticipate changes in conditions such as sea level rise or changing water availability due to climate change. It is relevant to project consideration under CEQA because climate change may result in changes in the environmental setting that would have a potentially significant effect on a proposed project.

4.1.4.4 CEQA and SB97

In its "Final Statement of Reasons for Regulatory Action, Amendments to the State CEQA Guidelines Addressing Analysis and Mitigation of Greenhouse Gas Emissions Pursuant to SB97," December 2009, the California Natural Resources Agency adopted amendments and additions to certain guidelines implementing CEQA. Specifically, these amendments implement the Legislature's directive to certify and adopt guidelines prepared and developed by the Office of Planning and Research for the mitigation of GHG emissions or the effects of GHG emissions (Pub. Resources Code, § 21083.05(a)-(b).

The amendments:

> focus on a project's potential incremental contribution of GHGs rather than on the potential effect itself (i.e., climate change). Notably, however, the Proposed Amendments expressly incorporate the fair argument standard. (See, e.g., proposed Section 15064.4(b)(3).) Thus, if there is any substantial evidence supporting a fair argument that a project's GHG emissions may result in any adverse impacts, including climate change, the lead agency must resolve that concern in an EIR.
>
> Section 15064.4 is designed to assist lead agencies in performing that required investigation. In particular, it provides lead agencies should quantify GHG emissions where quantification is possible and will assist in the determination of significance, or perform a qualitative analysis, or both as appropriate in the context of the particular project, in order to determine the amount, types and sources of GHG emissions resulting from the project. Regardless of the type of analysis performed, the analysis must be based "to the extent possible on scientific and factual data.

Section 15064 also states:

> (b) A lead agency should consider the following factors, among others, when assessing the significance of impacts from greenhouse gas emissions on the environment:
>
> (1) The extent to which the project may increase or reduce greenhouse gas emissions as compared to the existing environmental setting;
>
> (2) Whether the project emissions exceed a threshold of significance that the lead agency determines applies to the project.
>
> (3) The extent to which the project complies with regulations or requirements adopted to implement a statewide, regional, or local plan for the reduction or mitigation of greenhouse gas emissions. Such requirements must be adopted by the relevant public agency through a public review process and must reduce or mitigate the project's incremental contribution of greenhouse gas emissions.

Currently no GHG plans apply to recreational travel and fuel use outside of metropolitan areas.

4.1.5 Energy – Alternative Fuels

AB 1007 directs the California Energy Commission, in partnership with CARB, to develop and adopt the State Alternative Fuels Plan to:

- Recommend policies, such as standards, financial incentives, research, and development programs, to stimulate the development of alternative fuel supply, new vehicles and technologies, and fueling stations.
- Evaluate alternative fuels using a full fuel cycle analysis of emissions of criteria air pollutants, air toxics, greenhouse gases, water pollutants, and other substances that are known to damage human health.
- Set goals to increase alternative fuels in 2012, 2017, and 2022 designed to ensure there are reductions in air pollution, water pollution, or any other substances that are known to damage human health (CEC 2007).

The Plan addresses a broad range of alternative vehicle/fuel systems and alternative ways to produce traditional fuels, such as biodiesel.

4.2 ENVIRONMENTAL SETTING

4.2.1 Existing Ambient Air Quality

The Project Area is scattered throughout the mountainous regions of California (Figure 1). The project sites are located in high elevation areas, generally from 4,100 to 10,000 feet above mean sea level, within five air basins comprising 10 air district jurisdictions. The primary sources of air pollution in the northern mountainous regions is transport from upwind urban areas such as the broader Sacramento Area and San Francisco Bay Area Air Basin (NSAQMD 2005) and local particulate matter from roads and wood burning. As shown in Table 4-1, all project air districts except Siskiyou County are designated non-attainment areas for the state PM_{10} standard. Most of the air districts are also non-attainment for state or state and federal ozone standards; Lassen, Plumas, Sierra, and Alpine Counties have unclassified state ozone designations (CARB 2010a). Butte, Plumas, Fresno, and Tulare Counties are also in non-attainment of state $PM_{2.5}$ standards.

4.2.2 Sensitive Receptors

Sensitive receptors to air quality impacts are generally defined by air districts as facilities that house or attract children, the elderly, people with illnesses, or others who are especially sensitive to the effects of air pollutants. Hospitals, schools, convalescent facilities, and residential areas are examples of sensitive receptors. The project trail systems and trailheads are located in national forests surrounded by undeveloped public land. Many of the trail routes traverse remote locations several miles from the nearest access road (see Figures 2 through 12D). There are no sensitive receptor facilities that directly abut the trailheads or the trail routes maintained by the project OSV Program.

Recreational visitors to the trailheads and trail systems are receptors to potential air quality impacts of the Project and are considered in this EIR analysis.

4.2.3 Energy Use and Greenhouse Gases

California is a major consumer of energy due to its large population, industry, and commerce. Because California is physically large and has developed sprawling metropolitan areas, the state has a historical dependence on transportation using petroleum-based fuel. Fuel use rises and falls slightly with economic conditions, but annual consumption of gasoline and diesel motor fuels is roughly 20 billion gallons per year (CEC 2007).

Table 4-1. CSA Snow Program Project Site Air Basins and Air District Non-Attainment Status

Air Basin	Air District	Non-Attainment Status	National Forest	Project Trail Site
Northeast Plateau	Siskiyou County APCD	State ozone standards	Klamath	Deer Mountain and Four Corners Medicine Lake
			Modoc	Doorknob
			Shasta-Trinity	Pilgrim Creek
	Lassen County APCD	State PM_{10} standards	Lassen	Bogard, Fredonyer, and Swain Mountain
Sacramento Valley	Shasta County AQMD	State ozone and PM_{10} standards	Lassen	Ashpan
	Tehama County AQMD	State ozone and PM_{10} standards	Lassen	Morgan Summit
	Butte County APCD	Federal and state ozone and state PM_{10} and state $PM_{2.5}$ standards	Lassen	Jonesville
Mountain Counties	Northern Sierra AQMD (Plumas, Sierra, Nevada Counties)	Plumas County: State PM_{10} standards and State $PM_{2.5}$ (Portola Valley) Sierra County: State PM_{10} standards Nevada County: Federal and state ozone and state PM_{10} standards	Plumas	Bucks Lake, La Porte, and Gold Lake
			Tahoe	Little Truckee Summit and Bassetts
	Placer County APCD	Federal and state ozone and state PM_{10}	Tahoe	China Wall
	El Dorado County APCD	Federal and state ozone and state PM_{10}	Eldorado	Silver Bear
Great Basin Valley	Great Basin Unified APCD (Alpine, Mono, Inyo Counties)	Alpine County: state PM_{10} standards Mono and Inyo Counties: State ozone, federal and state PM_{10} standards	Inyo	Mammoth Lakes
			Stanislaus	Lake Alpine, Spicer Reservoir, and Highway 108
San Joaquin Valley	San Joaquin Valley Unified APCD (Fresno, Tulare Counties)	Federal and state ozone, federal and state $PM_{2.5}$, and state PM_{10} standards	Sierra	Huntington Lake, Kaiser Pass, and Tamarack Ridge
			Sequoia	Big Meadow/Quail Flat, Quaking Aspen/ Sugarloaf, and Kern Plateau

Lassen, Plumas, Sierra, and Alpine Counties have unclassified state ozone designations

Source: CARB 2010a

Transportation fuel use is a large component of GHG emissions. The statewide 2008 GHG inventory was 4778 MMT (million metric tons), of which 36.6% is attributed to transportation (CARB 2010b).

4.3 PROJECT IMPACTS

4.3.1 Thresholds of Significance

4.3.1.1 Air Quality

CEQA Guidelines Appendix G identifies the following thresholds, which are used in the EIR analysis, for assessing air quality impacts:

“Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:

- Conflict with or obstruct implementation of the applicable air quality plan?
- Violate any air quality standard or contribute substantially to an existing or projected air quality violation?
- Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?
- Expose sensitive receptors to substantial pollutant concentrations?
- Create objectionable odors affecting a substantial number of people?”

4.3.1.2 Energy Use

CEQA Guidelines Appendix F states that a discussion of a project’s energy impacts should be included “with particular emphasis on avoiding or reducing inefficient, wasteful and unnecessary consumption of energy.” CEQA Guidelines do not specify quantitative thresholds for assessing the significance of energy consumption impacts. In the absence of specific thresholds, the following significance criterion used to assess the Project’s energy impact:

- Is project energy consumption inefficient, wasteful, or unnecessary?

4.3.1.3 Greenhouse Gases

CEQA Guidelines Appendix G identifies the following thresholds for assessing greenhouse gas emission impacts:

“Would the project:

- Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?
- Conflict with any applicable plan, policy, or regulation adopted for the purpose of reducing the emissions of greenhouse gases?”

The OHMVR Division has not adopted its own quantitative standards of significance for GHG emissions and potential global climate change impacts. There are currently no locally adopted quantitative thresholds which apply to this statewide activity, and there are no statewide quantitative thresholds that apply to this project.

The CEQA guidelines as amended do not specify a methodology for analysis of GHG. In fall 2008, CARB staff began developing a decision process leading to qualitative and quantitative determination of significance. Most of the CARB staff process pointed to performance standards that are not transferable to the OSV Program, such as efficiency, reduction of waste, and minimizing transportation needs. One example of a draft performance standard was no more than 14,000 vehicle miles traveled per household per year. That standard was meant to apply to analysis of employment commute and access to services. It does not take into account long distance recreational travel such as the destination trips considered in this EIR.

Several metropolitan air districts have begun to set quantitative thresholds for GHG. Except for the passenger vehicle trips transporting the recreation traveler to and from the Project Area, none of the OSV Program project activities would take place in those urban districts, but the thresholds used by those districts are indicative of the scale of GHG emissions that rise to significance in California land planning. The South Coast Air Quality Management District (SCAQMD) interim CEQA GHG significance thresholds of 10,000 metric tons of carbon dioxide equivalent ($MTCO_2e$) per year for stationary/industrial projects and 3,000 $MTCO_2e$ per year for commercial or residential projects. The San Joaquin Valley Air Pollution Control District (SJVAPCD) adopted a performance-based approach that emphasizes land use planning and equipment efficiency to achieve AB32 GHG reduction goals. The Bay Area Air Quality Management District (BAAQMD) CEQA guidelines set a threshold of 10,000 $MTCO_2e$ per year for industrial stationary sources. For residential, commercial, and public land use projects, the BAAQMD has set a mass threshold of 1,100 MTCO2e per year and an efficiency-based threshold of 4.6 $MTCO_2e$ per service population per year. The 4.6 $MTCO_2e$ per service population per year significance threshold was derived from AB32-related GHG inventory estimates, and is an efficiency metric that allows efficient projects with higher mass emissions to meet the overall GHG reduction goals of AB32. The service population for a particular area or project is calculated by adding the number of residents to the number of jobs estimated for a given time period. The total GHG emissions estimated to occur at that time is then divided by the service population estimate to arrive at the average GHG emissions per service population per year. The derivation of the BAAQMD's project level efficiency threshold may be found in Appendix D to the BAAQMD's June 2010 CEQA Air Quality Guidelines (BAAQMD 2010).

4.3.2 Air Quality

The proposed Project comprises contracts to support maintenance of OSV recreation facilities in 11 national forests within the Project Area. The project funding would continue an established program meeting an existing demand for OSV recreation. The historical and ongoing OSV Program activity constitutes a baseline for assessing environmental impacts, including air quality. As described in Project Description, Section 2.7 OSV Program Growth Levels, future growth in snowmobile use similar to the past 12 years would result in a roughly 4% annual increase in program activity.

The direct emissions from project snow removal and trail grooming equipment and indirect emissions from recreational use and visitor travel begin at current 2010 baseline levels and may rise over the 10-year project term, reflecting continued historical trends in snowmobile registrations (see Project Description, Section 2.7 OSV Program Growth Levels). The calculation series and source data are shown in Appendix E, Air Quality, Energy, and Greenhouse Gases Assessment – Supporting Calculations as Tables AQ-1 through AQ-32. The discussion here focuses on summary results and conclusions; the reader is referred to Appendix E for detail.

4.3.2.1 Project Baseline – Existing Program Activity in Years 2010 and 2020

This section estimates the direct and indirect emissions that would occur in Years 2010 and 2020 under the existing Snow Program level condition. Under this condition, there would be no increase in direct plowing or grooming activities or indirect recreational OSV and vehicle miles travelled over the 10-year period from 2010 to 2020. The impacts that would occur under the program growth scenario outlined in Section 2.7 of the Project Description are analyzed beginning in Section 4.3.2.2.

The Project Baseline condition assumes that the existing OSV Program facilitates all of the indirect OSV and non-motorized recreational activities described in Section 2.6 of the Project Description. This assumption is conservative (i.e., an over-estimate of OSV Program share) since Winter Trailhead Survey data indicates that almost one-third (27 to 30%) of recreational users would continue to use trailheads regardless of the OSV Program's direct grooming and plowing activities (see Section 2.6.1.2 of Project Description).

Project Emissions

Direct Emissions: Snow Removal and Trail Grooming. The Project involves the operation of on-road diesel equipment for snowplowing, non-road diesel equipment for trail grooming, and a light duty service vehicle for cleaning restrooms and warming huts. All vehicles would be operated on minimum snow depths of 12 inches (snowcats) or on paved roads (snowplows and service vehicle). Because no ground disturbance activity is proposed, there would be essentially no fugitive dust or PM_{10} emissions from vehicle travel on dirt roads. The main air pollutant emissions are from internal combustion engines.

The grooming equipment listed in the Project Description (Table 2-4) and Appendix E (Table AQ-18) is typically 240 to 400 horsepower. Emissions factors for diesel are given in grams per brake horsepower–hour (or a metric equivalent for work). Because snow grooming power levels vary with conditions and because actual fuel use information is available from most of the national forests (Appendix E, Table AQ-17), it is practical to base emissions estimates on fuel consumption. Because the analysis is based on overall fuel use, it takes into account emissions from travel to the work site from the grooming shed as well as work at the site.

The potential air quality impact of the project equipment is assessed by looking at the maximum day emissions and the annual (seasonal) total emissions. National forests typically operate one grooming machine and one snowplow and/or blower at each trail site location. Some national forests share grooming equipment; Klamath National Forest grooms on Modoc National Forest at the Doorknob and Tahoe National Forest grooms on Plumas National Forest at Gold Lake. The one exception is Jonesville in Lassen National Forest, which is groomed by a volunteer group through agreement with Butte County. The volunteers operate two snowcats, one owned by the volunteers and one owned by the county (see Project Description, Table 2-7 and Appendix E, Table AQ-14). Snow removal at project trailhead locations, which is conducted separately from the OSV Program funding (see Project Description, Table 2-6), is not included in this assessment. Emissions estimated at each location reflect the number of snow removal and grooming machines used and the composition of the equipment fleet and applicable emissions standards.

The 11 national forests in the Project Area have trailheads and trail systems located in ten different air districts. Table 4-2 lists the air districts, their respective trailheads, and typical equipment used at each.

Table 4-2. Maximum-Day Equipment Operations Per Air District

Air District	National Forest	Project Trail Sites	Max Daily Equipment Operations
Siskiyou County APCD	Klamath	Deer Mountain and Four Corners Medicine Lake	1 snowcat – 16 hrs 1 plow or blower – 7hrs
	Modoc	Doorknob	1 plow or blower – 8 hrs
	Shasta-Trinity	Pilgrim Creek	1 snowcat – 13 hrs 1 plow or blower – 16 hrs
Lassen County APCD	Lassen	Bogard and Fredonyer	1 snowcat – 12 hrs
	Lassen	Swain Mountain	1 snowcat – 12 hrs 1 plow or blower – 6 hrs
Shasta County APCD	Lassen	Ashpan	1 snowcat – 12 hrs
Tehama County APCD	Lassen	Morgan Summit	1 snowcat – 12 hrs
Butte County AQMD	Lassen	Jonesville	2 snowcat – 25 hrs total 1 plow and blower – 18 hrs
Northern Sierra AQMD	Plumas	Bucks Lake	1 snowcat – 12 hrs 1 plow or blower – 8 hrs
	Plumas	La Porte	1 snowcat – 12 hrs 1 plow or blower – 2 hrs
	Plumas	Gold Lake	1 plow or blower – 6 hrs
	Tahoe	Bassetts	1 snowcat – 12 hrs
	Tahoe	Little Truckee Summit	1 snowcat – 15 hrs 1 plow or blower – 8 hrs
Placer County APCD	Tahoe	China Wall	1 snowcat – 10 hrs 1 plow or blower – 2 hrs
El Dorado County APCD	Eldorado	Silver Bear	1 snowcat – 10 hrs
Great Basin Unified APCD	Stanislaus	Lake Alpine	1 snowcat – 12 hrs
	Stanislaus	Spicer Reservoir	1 snowcat – 12 hrs
	Stanislaus	Highway 108	1 snowcat – 12 hrs
	Inyo	Mammoth Lakes	1 snowcat – 9 hrs
San Joaquin Valley Unified APCD	Sierra	Huntington Lake/Kaiser Pass	1 snowcat – 12 hrs
	Sierra	Tamarack Ridge	1 snowcat – 12 hrs
	Sequoia	Big Meadow/Quail Flat, Quaking Aspen/Sugarloaf	1 snowcat – 12 hrs
	Sequoia	Kern Plateau	1 snowcat – 12 hrs 1 plow or blower – 11hrs

Notes:
Total equipment hours operated in one day based on maximum daily snowcat and plow use in Table 2-2. Assumes plowing and grooming occurs on same day. Snow removal on roads and parking areas done by either plow or blower dependent upon snow accumulation. Snow removal on roads and parking area are listed only for areas plowed using CSA funds per Table 2-6.
Emissions within each air basin do not occur on same day and therefore cannot be combined to create a daily project total.
Doorknob is groomed by Klamath NF. Grooming hours are included with Deer Mountain and Four Corners Medicine Lake. Gold Lake is groomed by contractors for Tahoe NF. Grooming hours are included with Bassetts.

Source: USFS 2009

PM and NOx are the principal pollutants of concern for heavy duty diesel engines. Snowcat emissions are based on off-road heavy diesel factors (Appendix E, Table AQ-19); snowplow emissions are based on on-road heavy diesel factors (Appendix E, Table AQ-20). Appendix E tables show how composite fleet emissions factors are calculated for heavy duty diesel and how fleet emissions factors are expected to change over the ten-year program term (Appendix E, Table AQ-21 and Table AQ-22). Although OHMVR Division grooming fleet equipment is listed by national forest, assignments will change due to equipment maintenance, replacement, and need. For this reason, a fleet average emission factor is used for all individual trail systems rather than calculations based on specific equipment currently assigned there.

The change in both on-road and off-road emissions factors will come about as heavy duty diesel fleets keep up with federal and state mandates. As explained in Project Description, Section 2.4.1 and listed in Project Description, Table 2-5, the OHMVR Division Snowcat Vehicle Fleet Replacement Plan is already underway and will contribute to newer, lower emissions equipment phased in over the 10-year program period. Specific emissions rates will decline significantly over the next ten years as shown in Table 4-3. PM_{10} emissions factors will fall to 29% and 19% of current levels for grooming and snow removal equipment, respectively. NOx emissions factors are predicted to fall to 36% and 11% of current levels for grooming and snow removal equipment.

Table 4-3. OSV Program Fleet Composite Emissions Factor, Change Over 10-Year Project Period (grams/gallon)

	Model Fleet Year			2020 Fleet as % of 2010
	2010	2015	2020	
PM_{10} Emissions Factor				
Grooming	8.50	4.72	2.49	29%
Snow-removal	1.44	0.35	0.27	19%
NOx Emissions Factor				
Grooming	147.9	89.2	53.0	36%
Snow-removal	75.1	32.0	8.2	11%

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Table AQ-23

Table 4-4 and Table 4-5 show pollutant emissions estimates for each trail site location, aggregated by air district. Emissions are shown for the “maximum day” as inferred from operating procedures, and for the season, based on overall fuel use data. Emissions are shown for program starting year 2010, for mid-point year 2015, and end year 2020. Table 4-4 and Table 4-5 are based on a constant activity scenario with heavy equipment use staying at 2008/2009 winter season levels, and the OSV Program growth identified in Project Description, Section 2.7 does not occur. The impacts of OSV Program growth over the next ten years is addressed in Section 4.3.2.6 below.

Project emissions estimates are based on a fleet average emissions factor applied to activity levels reported for 2009 at individual trailheads. The snow grooming fleet has equipment varying in age and emissions profile. Actual emissions at a specific trail site would vary from estimates and would depend on what equipment is assigned there and on actual work done, which depends mainly on weather and snow fall.

Table 4-4. Grooming and Plowing PM_{10} Emissions by National Forest and Air District, Constant Project Activity at Baseline Level

Air District	National Forest	Max Day (pounds)			Season (pounds)		
		2010	2015	2020	2010	2015	2020
Siskiyou APCD	Klamath	2.7	1.4	0.8	44	24	13
	Modoc	0.2	0.1	0.0	2	1	0
	Shasta-Trinity	2.5	1.2	0.7	44	22	12
	Subtotal	5.4	2.7	1.5	90	47	25
Shasta County AQMD	Lassen	1.9	1.0	0.6	39	22	11
Lassen County APCD	Lassen	3.9	2.1	1.1	122	67	36
Tehama County AQMD	Lassen	1.9	1.0	0.6	47	26	14
Butte County APCD	Lassen	4.4	2.3	1.2	71	38	20
Northern Sierra AQMD	Plumas	4.2	2.2	1.2	126	61	34
	Tahoe	4.4	2.4	1.3	125	68	36
	Subtotal	8.6	4.6	2.5	251	129	70
Placer County APCD	Tahoe	1.6	0.9	0.5	22	12	6
El Dorado County APCD	Eldorado	1.6	0.9	0.5	24	13	7
Great Basin Unified APCD	Inyo	1.4	0.8	0.4	31	17	9
	Stanislaus	5.6	3.1	1.7	37	20	11
	Subtotal	7.1	3.9	2.1	67	37	20
San Joaquin Valley Unified APCD	Sierra	3.8	2.1	1.1	56	31	16
	Sequoia	4.1	2.2	1.2	41	21	11
	Subtotal	7.8	4.2	2.3	98	52	28
	Total	**44.1**	**23.7**	**12.7**	**831**	**444**	**237**
					0.42 tons	0.22 tons	0.12 tons

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Table AQ-24

Table 4-5. Grooming and Plowing NOx Emissions by National Forest and Air District, Constant Project Activity at Baseline Level

Air District	National Forest	Max Day (pounds) 2010	2015	2020	Season (pounds) 2010	2015	2020
Siskiyou APCD	Klamath	53.3	30.4	16.7	826	483	275
	Modoc	11.1	4.7	1.2	116	50	13
	Shasta-Trinity	57.6	30.8	15.1	979	533	270
	Subtotal	122.0	66.0	33.0	1921	1066	558
Shasta County AQMD	Lassen	32.7	19.7	11.7	679	409	243
Lassen County APCD	Lassen	73.8	43.0	24.4	2140	1285	759
Tehama County AQMD	Lassen	32.7	19.7	11.7	818	493	293
Butte County APCD	Lassen	93.1	51.7	27.2	1395	797	438
Northern Sierra AQMD	Plumas	87.6	48.9	25.9	3238	1677	772
	Tahoe	84.7	49.1	27.6	2285	1347	776
	Subtotal	172.3	98.0	53.5	5523	3025	1548
Placer County APCD	Tahoe	30.0	17.6	10.1	418	244	139
El Dorado County APCD	Eldorado	27.3	16.4	9.8	409	247	147
Great Basin Unified APCD	Inyo	24.5	14.8	8.8	532	321	191
	Stanislaus	98.2	59.2	35.2	638	385	229
	Subtotal	122.7	74.0	44.0	1170	705	419
San Joaquin Valley Unified APCD	Sierra	65.5	39.5	23.4	979	590	351
	Sequoia	80.7	46.0	25.1	917	500	254
	Subtotal	146.1	85.4	48.6	1896	1090	605
	Total	**853**	**492**	**274**	**16,370**	**9,361**	**5,149**
					8.19 tons	4.68 tons	2.57 tons

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Table AQ-25

Maximum day emissions at locations where there is only one trail site per air district are typically 1.6 to 1.9 pounds per day for PM_{10} (Table 4-4) and 27 to 33 pounds per day for NOx (Table 4-5) and. Emissions in any air district depend on how many trail sites are located there, and maximum day emissions depend on how many trail sites are actually groomed on the same day. The state-wide maximum day totals shown in Table 4-4 and Table 4-5 are an over estimate because they sum the predicted individual maximum day emissions, but it is unlikely that all plowed access and trailheads and groomed trail systems would receive maximum effort on the same day, state-wide.

Seasonal emissions are a broad range reflecting the range of snow conditions and user demand. Seasonal emissions in air basins with only one groomed trail site can range from 22 to 47 pounds PM_{10} (Table 4-4) and 409 to 818 pounds NOx (Table 4-5). Aggregated air district-wide totals vary depending on the number of trail sites and weather conditions. Statewide season totals are a reasonable estimate of direct air pollutant generation.

Indirect Emissions: OSV Use. OSV use of the project trails facilitated by the project activities would generate vehicle emissions. These are an indirect effect of the Project, although some level of OSV use would continue with or without grooming and plowing.

At the beginning of the Project in 2010, OSV use would not be changed compared to past use facilitated by the OSV Program, and indirect emissions from OSV use would remain similar to the historical baseline. Possible growth in OSV use over the 10-year program period is discussed in Section 4.3.2.2. National forests do not keep visitation records for all locations. Annual OSV use of the project sites are estimated in Project Description, Table 2-8. The maximum day is a weekend day or holiday; it is based on vehicle parking observed by the national forests. The seasonal use is based on 14 weeks from mid-December through March, which includes 33 weekend/holidays at maximum day use level and 65 weekdays at 20% parking capacity use. Both maximum day and seasonal use totals assume an average of two OSVs per vehicle parked at project trailheads and other non-program parking areas (Table 2-9).

OSV fleet estimates for the 2010 baseline year are 96% two-stroke and 4% four-stroke based on visitor survey data (refer to Project Description, Table 2-9). Existing CARB model OFFROAD 2007, a software package used to generate emissions inventory data for off-road mobile sources, does not take into account four-stroke OSV (CARB 2007b). A composite emissions factor relating emissions measurements to fuel use was developed based on Lela and White (2002); see Appendix E, Table AQ-1. A typical two-stroke OSV would use 8 gallons during a recreation day. Fuel use, visitor levels, and emissions factors research allow derivation of an emissions estimate for OSV use in the Project Area supported by the OSV Program.

Table 4-6 presents maximum day emissions for the affected air districts at current levels of OSV use at trail sites and current emissions factors. The difference in technology between OSV two-stroke gasoline engines and grooming and plowing heavy-duty diesel engines produces a very different emissions profile. The main air pollutants from OSVs are hydrocarbons and carbon monoxide: HC levels are typically from 300 to 900 pounds per day at a trail site, depending on use level, and CO levels are typically from 750 to 2,400 pounds per day. Conversely, baseline 2010 PM and NOx levels are lower than direct emissions from project equipment: PM levels are typically from 3.6 to 12 pounds per day at a trailhead, depending on use level; NOx levels are typically from 1.6 to 5 pounds per day. The total emissions identified for the air district reflect the number and use levels of trail sites located there.

Table 4-6. OSV Max Day Use Emissions by Air District – Baseline 2010

Air District	National Forest	Trailheads	Max Day OSV	Fuel Use (gal)	Max Day Use Emissions (lb)			
					HC	CO	NOx	PM
Siskiyou APCD	Klamath	2	92	724	1,253	3,449	7.2	16.4
	Modoc	1	30	236	409	1,125	2.4	5.3
	Shasta-Trinity	1	50	394	681	1,874	3.9	8.9
Subtotal			**172**	**1,354**	**2,343**	**6,448**	**14**	**31**
Shasta County AQMD	Lassen	1	28	220	381	1,050	2.2	5.0
Lassen County APCD	Lassen	4	136	1,071	1,853	5,098	10.7	24.2
Tehama County AQMD	Lassen	1	28	220	381	1,050	2.2	5.0
Butte County APCD	Lassen	1	20	157	272	750	1.6	3.6
Northern Sierra AQMD	Plumas	4	560	4,408	7,629	20,992	44.1	99.8
	Tahoe	2	340	2,676	4,632	12,745	26.8	60.6
	Tahoe	--	86	677	1,172	3,224	6.8	15.3
Subtotal			**986**	**7,762**	**13,432**	**36,961**	**78**	**176**
Placer County APCD	Tahoe	1	64	504	872	2,399	5.0	11.4
El Dorado County APCD	Eldorado	1	30	236	409	1,125	2.4	5.3
Great Basin Unified APCD	Inyo	--	904	7,116	12,315	33,887	71.2	161.2
	Stanislaus	3	960	7,557	13,078	35,987	75.6	171.1
Subtotal			**1,864**	**14,673**	**25,393**	**69,874**	**147**	**332**
San Joaquin Valley Unified APCD	Sierra	3	460	3,621	6,266	17,244	36.2	82.0
	Sierra	--	150	1,181	2,043	5,623	11.8	26.7
	Sequoia	9	152	1,197	2,071	5,698	12.0	27.1
	Sequoia	--	44	346	599	1,649	3.5	7.8
Subtotal			**806**	**6,345**	**10,980**	**30,214**	**63**	**144**
	Total	**34**	**4,134**	**32,543**	**56,316**	**154,967**	**325**	**737**

Notes:

Tahoe, Inyo, Sierra, and Sequoia National Forests have non-OSV Program funded parking areas which contribute OSV use to the groomed trail system. OSV use from these non-program trailheads are included in calculations.

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Table AQ-6

Table 4-7 presents season emissions estimates for the affected air districts at current (Baseline 2010) levels of OSV use at trail sites and current emissions factors. The two-stroke OSV fleet produces high hydrocarbon (ROG) emissions – an estimated 1,081 tons per year spread over ten air districts. On an annualized basis this is 3.0 tons per day as ROG and 0.017 tons per day NOx.

Table 4-7. OSV Season Use Emissions by Air District – Baseline 2010

Air District	National Forest	Trailheads	Season OSV-days	Fuel Use (gal)	Seasonal Emissions (tons)			
					HC	CO	NOx	PM
Siskiyou APCD	Klamath	2	5,506	43,343	38	103	0.2	0.5
	Modoc	1	1,510	11,887	10	28	0.1	0.1
	Shasta-Trinity	1	2,300	18,106	16	43	0.1	0.2
Subtotal			**9,316**	**73,336**	**63**	**175**	**0.4**	**0.8**
Shasta County AQMD	Lassen	1	**1,340**	**10,548**	**9**	**25**	**0.1**	**0.1**
Lassen County APCD	Lassen	4	**7,296**	**57,434**	**50**	**137**	**0.3**	**0.7**
Tehama County AQMD	Lassen	1	**1,340**	**10,548**	**9**	**25**	**0.1**	**0.1**
Butte County APCD	Lassen	1	**972**	**7,652**	**7**	**18**	**0.0**	**0.1**
Northern Sierra AQMD	Plumas	4	22,250	175,152	152	417	0.9	2.0
	Tahoe	2	12,910	101,628	88	242	0.5	1.2
	Tahoe	--	4,086	32,165	28	77	0.2	0.4
Subtotal			**39,246**	**308,945**	**267**	**736**	**1.5**	**3.5**
Placer County APCD	Tahoe	1	**2,944**	**23,175**	**20**	**55**	**0.1**	**0.3**
El Dorado County APCD	Eldorado	1	**1,770**	**13,933**	**12**	**33**	**0.1**	**0.2**
Great Basin Unified APCD	Inyo	--	17,152	135,021	117	321	0.7	1.5
	Stanislaus	3	40,260	316,927	274	755	1.6	3.6
Subtotal			**57,412**	**451,947**	**391**	**1,076**	**2.3**	**5.1**
San Joaquin Valley Unified APCD	Sierra	3	21,160	166,572	144	397	0.8	1.9
	Sierra	--	6,900	54,317	47	129	0.3	0.6
	Sequoia	9	7,174	56,474	49	134	0.3	0.6
	Sequoia	--	1,868	14,705	13	35	0.1	0.2
Subtotal			**37,102**	**292,067**	**253**	**695**	**1.5**	**3.3**
	Total	**34**	**158,738**	**1,249,586**	**1,081**	**2,975**	**6.2**	**14.1**

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Table AQ-7

Emissions factors of the OSV vehicle fleet using the Project Area may change over time affecting emission totals generated by the 2010 baseline level. Future OSV emissions factors over the 10-year program period are not easily predicted. Federal regulations are in place, but have been partially suspended by court action, and will apply to a fleet as sold by a manufacturer. New OSVs will undoubtedly have lower emissions, either through improved two-stroke technology or through use of four-stroke engines. Either approach would reduce emissions and improve fuel efficiency. This EIR uses a mix of older and newer OSVs to develop project 2020 emissions factors shown in Table 4-8. Improved emissions factors would cause OSV emissions in the Project Area at 2010 use levels to drop in HC, CO, and PM emissions. However, increased reliance on four-stroke engines would increase fleet NOx emissions as shown in Table 4-8.

Table 4-8. Average Day OSV Use Emissions per Machine

	Fuel Use gallons	lb pollutant/OSV/day			
		HC	CO	NOx	PM
Baseline 2010	7.87	13.62	37.49	0.08	0.18
Project 2020	6.72	9.14	26.03	0.17	0.12
2020 as % of 2010	85%	67%	69%	212%	67%

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Table AQ-11

Indirect Emissions: Passenger Vehicle Travel. Indirect vehicle emissions are generated by recreational user travel to and from project maintained trailheads. Trailheads are located in areas relatively remote from population centers, and trailhead travel results in substantial vehicle miles traveled. According to the Winter Trailhead Survey (Appendix A, Table 5), the average round-trip distance is typically about 205 miles, reflecting the location of the trailheads (majority are 5,000 feet to 6,000 feet elevation in the Sierra Nevada) and the population centers they serve (e.g., Stockton, Sacramento, Chico, Oroville, Reno, Live Oaks). Users traveling farther include out-of-state visitors; some 20,000 non-resident visitor passes are sold system wide, but that statistic includes non-winter permits for other OHVs as well as snowmobiles and other OHVs. Because point of origin and destination details are not tracked, the vehicle miles travelled within each air district and the resulting emissions produced are unknown. The average statewide emissions generated by user vehicle miles traveled (VMT), however, is a reasonable estimate of the air pollution generated by this indirect source.

OSV haul vehicles are typically pick-up trucks or sport utility vehicles (SUVs) with high fuel consumption when towing (estimated as 12 mi/gal). Transportation is estimated to be some 79,000 visitor vehicle-days in baseline year 2010 rising to a possible 117,000 vehicle-days in 2020. Taking into account multiple day use per trip and travel to overnight accommodation, the program supported recreation entails highway travel of roughly 20 million miles per year in 2010, rising to as much as 29 million miles in 2020 (Appendix E, Table AQ-13). Fuel use is addressed under energy and greenhouse gases below.

The 2010 baseline average statewide emissions are presented in Table 4-9 below. The emissions estimates were calculated using CARB's Emission Factors (EMFAC) model-derived weighted average emission factors for engine exhaust and other trip emissions sources (e.g., start-up, idling, etc.) developed from the model's 2010 statewide Burden mode planning emission inventory data. The estimate assumes user vehicles would consist of light-, medium-, and light-heavy-duty pick-up trucks.

Table 4-9. 2010 Statewide Seasonal User VMT Emissions

	Seasonal VMT (Million Miles)	Seasonal Emissions (tons)			
		HC	CO	NOx	PM
User Vehicles	**19.5**	7.3	76.8	12.5	0.94

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Table AQ-31

The baseline emissions generated per unit of travel in terms of grams/mile and grams/trip would decrease over time due to stricter passenger vehicle emissions standards and fleet turnover rates for all pollutants except PM. Table 4-10 compares the 2010 and 2020 EMFAC-derived composite weighted average emission factors for light-, medium-, and light-heavy-duty trucks.

Table 4-10. User VMT Emissions

	Emission Factors							
	HC		CO		NOx		PM	
	g/mi	g/trip	g/mi	g/trip	g/mi	g/trip	g/mi	g/trip
Baseline 2010	0.33	1.05	3.53	7.91	0.58	0.68	0.04	0.01
Project 2020	0.20	0.61	1.63	4.04	0.25	0.35	0.05	0.01
2020 as % of 2010	59%	58%	46%	51%	43%	52%	107%	117%

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Tables AQ-29 and AQ-30

Air Quality Impact

This section analyzes the impacts of Year 2010 and Year 2020 emissions levels under the Project Baseline condition. Table 4-11 summarizes the emissions that would occur under this condition.

Table 4-11. Project Baseline Emissions Summary

Emission Source	**2010 Baseline Pollutant Emissions (tons)**			
	HC	**CO**	**NOx**	**PM**
Direct				
Plowing and Grooming	--	--	8.2	0.4
Indirect				
OSV Use	1,081	2,975	6.2	14.1
Visitor Travel	7.3	76.8	12.5	0.94
Subtotal	1,088	3,052	18.7	15.0
Year 2010 Total	1,088	3,052	26.9	15.4
Emissions Source	**2020 Baseline Pollutant Emissions (tons)**			
	HC	**CO**	**NOx**	**PM**
Direct				
Plowing and Grooming	--	--	2.6	0.1
Indirect				
OSV Use	726	2,066	13.3	9.5
Visitor Travel	4.3	35.4	5.4	1.0
Subtotal	730	2,101	18.7	10.5
Year 2020 Total	730	2,101	21.3	10.6

Source: TRA Environmental Sciences, Inc. 2010; Compiled from Tables 4-4, 4-5, 4-7 through 4-10, and Appendix E Tables AQ-12 and AQ-32.

Air Quality Plans

Direct Emissions: Snow Removal and Trail Grooming. Direct project emissions would not conflict with or obstruct implementation of the applicable air quality plan. There are no air quality plans in place that directly govern statewide mobile source emissions from the project snow removal and trail grooming equipment. Project equipment emissions are regulated by CARB through vehicle fleet requirements. OHMVR Division snowcat equipment is required to comply with CARB standards and regulations. Other agencies and contractors who own and operate the snow removal equipment are likewise responsible for compliance with CARB requirements for on-road heavy-duty vehicles. Therefore, the Project has no effect on air quality plans.

The Project would not conflict with state or local Air Quality Management Plans. Direct and indirect air pollutant emissions from an ongoing program are already incorporated in emissions inventories and are taken into account in air quality planning. All program emissions are from internal combustion engines, which are regulated at the federal or state level. Recreational OSV use levels are not restricted by state regulation or by local air districts.

The project-supported activities are mainly operation of snow grooming and plowing equipment (see Project Description, Table 2-1) and a light duty service vehicle used to service restrooms and warming huts. The Project does not involve new land uses, contribute to urban growth, or introduce new stationary sources of air pollutants into the air basins. As such, the Project would not result in the violation of Air Quality Management Plans implemented by the various air districts associated with the project site locations within the Project Area.

The Project would facilitate winter use of USFS-approved recreational trails by OSVs. Project activities and subsequent visitor use of project trails and facilities for OSV recreation are consistent with the purposes of the Land Resource Management Plans or Forest Plans governing the national forests.

Indirect Emissions: OSV Use. Indirect emissions from OSV use would not conflict with or obstruct implementation of an applicable air quality plan because there are no plans in place that govern OSV user emissions. The individual emissions generated by each OSV would be required to meet applicable emissions standards set by the EPA and CARB. The project effect is less than significant.

Indirect Emissions: Passenger Vehicle Travel. Emissions from passenger vehicles traveling to the Project Area are part of on-highway vehicle travel accounted for in the statewide transportation inventory and in basin attainment plans maintained by individual air districts. The emissions from passenger trips to the Project Area are included in baseline conditions and do not represent new emissions. The emissions do not conflict with air quality plans.

Air Quality Standards and Nonattainment Regions

Direct Emissions: Snow Removal and Trail Grooming. Direct project emissions at current levels represent a continuation of baseline conditions. All direct project emissions are presently occurring and have been occurring for many years. Possible growth in the OSV Program and offsetting declines in equipment emission factors over the 10-year program period is discussed in Section 4.3.2.2.

Off-road and on-road heavy-duty vehicle emissions associated with the Project are generically included in the state's inventory of air pollutants and are therefore part of baseline conditions. By the nature of the operation, grooming equipment operates at night and moves continually over many miles of trail such that there are no localized concentrations of exhaust emissions. Likewise, plowing also occurs over several miles of access road and at multiple trailhead parking locations. Local concentrations of air pollutants from equipment exhaust would be low and very short duration only occurring intermittently over the 4-month winter season (December to

March). Concentrations would not approach significance thresholds for diesel particulate matter or ambient air quality standards for other pollutants.

With the exception of Lassen County APCD and parts of Northern Sierra AQMD and Great Basin Unified APCD, air districts within the Project Area are in non-attainment for state ozone standards. The regional impact of NOx emissions is minimal during the cold winter season when conditions do not favor formation of ozone. Therefore, the impact of the project equipment emissions on contribution of ozone to a non-attainment air basin in the Project Area is less than significant.

With the exception of Siskiyou County APCD all of the 10 air districts within the Project Area are in non-attainment with state PM_{10} standards. Project PM_{10} emissions occur in areas remote from other existing sources. Elevated PM_{10} levels in the non-attainment air districts in the Project Area are largely associated with fugitive dust from unpaved surfaces, which are covered by snow during the winter season, or from wood burning in settled areas away from the trail sites. Therefore, project PM_{10} emissions occur when high background PM_{10} levels are not present. For these reasons, the Project is not likely to violate air quality standards or contribute significantly to PM_{10} or levels in non-attainment regions. The Lake Tahoe air basin is known to have elevated PM_{10} levels during the winter season; however, the OSV Program supported trail systems and trailheads are located outside of this sensitive air basin.

Indirect Emissions: OSV Use. OSVs are classified as OHVs which are included in the emission inventories prepared by each air district. As an example, in 2005, off-highway recreation vehicles accounted for three percent (1.775 tons/day) of ROG emissions and one-tenth of one percent (0.106 tons/day) of NOx emissions from mobile sources throughout the Northern Sacramento Planning Area (NSVPA 2006). OSV use on OSV Program supported trails is a component of those inventories and part of baseline conditions.

OSVs contribute NOx and ROG emissions to air basins, most of which are in non-attainment for ozone. OSV ROG and NOx emissions, however, occur during the winter when low temperatures and low sunlight conditions do not favor formation of ozone. OSV use is also spread out over a network of trails served by the trailhead. Although there would be higher localized emissions at the staging areas, for the most part, the maximum day emissions shown in Table 4-6 are dissipated over upwards of 30 miles of trail over a period of 6 hours or more. There are no localized concentrations of exhaust emissions approaching ambient air quality standards. The project effect would be less than significant.

Indirect Emissions: Passenger Vehicle Travel. Emissions from passenger vehicles traveling to the Project Area are part of on-highway vehicle travel accounted for in the statewide transportation inventory and in basin attainment plans maintained by individual air districts. The emissions from passenger trips to the Project Area are included in baseline conditions and do not represent new emissions. The indirect visitor travel emissions impact is less than significant.

Sensitive Receptors and Odors

Direct Emissions: Snow Removal and Trail Grooming. There are no sensitive receptors near emissions sites. Generally, grooming and plowing takes place when no recreational users are present, so there is no overlap of direct and visitor emissions. Direct emissions would not expose sensitive receptors to substantial pollutant concentrations, or create objectionable odors affecting a substantial number of people. The project effect is less than significant.

Indirect Emissions: OSV Use. The Project would not expose sensitive receptors to substantial pollutant concentrations, or create objectionable odors affecting a substantial number of people. Odor impact depends on the intensity of the odor, its frequency and duration, and the offensiveness of the odor. The ROG and PM emissions from two-stroke engines include unburned fuel and lubricating oil mixed with fuel. Two-stroke exhaust has a characteristic odor and can be recognized along the trail or for several hundred feet off trail, depending on traffic level and wind. The exhaust odor is concentrated on trails where OSVs are in use and exposes OSV and non-OSV recreation users. The main measure of impact depends on the perceived offensiveness of the odor. The OSV user community is used to the odor and associates it with voluntary outdoor recreation. For some the odor is considered tolerable in association with the recreation. Others associate it with a form of recreation often perceived as incompatible with non-motorized recreation and is thus more likely to find the odor offensive. To the non-motorized recreationist, the exhaust simply “smells bad” and is discordant with the expectation of a clean outdoor atmosphere.

The OSV Program services groomed trails and trailheads used by OSV and non-OSV recreation. The visitor survey reported in Project Description, Section 2.6 and Table 2-9 indicates that roughly 89% of trailhead visitors were there for motorized recreation and 14% engaged in either snowshoeing or cross-country skiing. The OSV trail system is multi-use and both non-motorized users and OSVs can overlap on the groomed trail as well as off-trail. The non-motorized user is aware of the motorized activity at the trailhead and presumably takes into account the presence of motorized use and associated traffic, noise, and odor may affect his own enjoyment. Because non-motorized use areas are available in nearly all national forest service areas, it is reasonable to conclude that non-motorized users judge odor and other impacts to be tolerable or they would go elsewhere. Because exposure is voluntary, short term (a few hours), and intermittent, it is concluded that the Project would not create objectionable odors affecting a substantial number of people. The project effect is less than significant.

Indirect Emissions: Passenger Vehicle Travel. Emissions from passenger vehicles traveling to the Project Area do not expose sensitive receptors to substantial pollutant concentrations or create objectionable odors affecting a substantial number of people. The project effect is less than significant.

4.3.2.2 10-Year Program Growth, Year 2020

This section estimates and compares the direct and indirect emissions that would occur in Year 2020 with OSV Program Growth. Under this condition, there would be an increase in direct plowing or grooming activities or indirect recreational OSV and vehicle miles travelled over the 10-year period from 2010 to 2020. Like the Project Baseline condition, the Program Growth condition also assumes that the existing OSV Program is responsible for all of the indirect OSV and non-motorized recreational activities described in Section 2.6 of the Project Description. This assumption is conservative (i.e., an over-estimate of OSV Program share) since Winter Trailhead Survey data indicates that almost one-third (27 to 30%) of recreational users would continue to use trailheads regardless of the OSV Program’s direct grooming and plowing activities (see Section 2.6.1.2 of Project Description).

Project Emissions

Direct Emissions: Snow Removal and Trail Grooming. Program growth would increase grooming and snow removal equipment use. The growth scenario defined in Project Description, Section 2.7.1 allows for up to 1,100 hours increase in annual grooming and 700 hours increase in annual snow removal program-wide by the year 2020. Actual levels of activity would depend on weather and user demand, and the projected growth may not occur. The location of the increase is not predicted, and the effect is evaluated for the OSV Program as a whole in Table 4-12.

Table 4-12. Grooming and Plowing Emissions, Increased Program Activity to 10-Year Growth Level

		Season (tons)		% Change
		2020 Baseline	2020 Program Growth	
Grooming	Hours	4,948	6,048	122%
	PM_{10}	0.39	0.14	36%
	NOx	6.7	3.0	44%
Plowing	Hours	2,076	2,776	134%
	PM_{10}	0.028	0.007	35%
	NOx	1.4	0.2	15%
Program Total	Hours	7,024	8,824	126%
	PM_{10}	0.42	0.15	35%
	NOx	8.2	3.2	39%
10-year growth scenario: Increase grooming by 1100 hours; increase plowing by 700 hours.				

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Table AQ-26

Indirect Emissions: OSV Use. Growth in OSV registrations is predicted to continue and is predicted to result in an approximately 4% annual growth in usage. Actual usage may be affected by economic conditions and would depend mainly on weather and length of the snow season. Table 4-13 summarizes indirect OSV Use emissions under Project Baseline and Program Growth Year 2020 conditions.

Table 4-13. OSV Emissions with Projected Increased Program Activity

	Season OSV-days	Fuel Use (gal)	Annual Emissions (tons)			
			HC	CO	NOx	PM
Baseline 2020	158,738	1,062,148	726	2,066	13.3	9.5
Program Growth 2020	234,932	1,578,745	1,074	3,057	19.6	14.1
Project 2020 is a 48% increase over Baseline 2010						

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Table AQ-12

Indirect Emissions: Passenger Vehicle Travel. The statewide emissions from vehicle travel to the Project Area under the 10-year program growth scenario are presented in Table 4-14. User vehicles and VMT are estimated to increase by 48%. Despite the growth in vehicles and VMT expected to occur the emissions from this source decrease below baseline levels for all pollutants except PM due to stricter emissions standards and fleet turnover.

Table 4-14. User VMT Emissions with Projected Increased Program Activity

	Seasonal Trips	Seasonal VMT (Million Miles)	Annual Emissions (tons)			
			HC	CO	NOx	PM
Baseline 2020	95,243	19.5	4.27	35.38	5.36	1.0
Project 2020	140,959	28.9	6.34	52.38	7.98	1.49
Project 2020 is a 48% increase over Baseline 2010						

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Tables AQ-32 and AQ-33.

Air Quality Impact

This section analyzes the impacts of Year 2020 emissions levels under the Program Growth condition. Table 4-15 summarizes the emissions that would occur under this condition.

Table 4-15. Program Growth Emissions Summary

Emission Source	2020 Baseline Pollutant Emissions (tons)			
	HC	CO	NOx	PM
Direct				
Plowing and Grooming	--	--	2.6	0.1
Indirect				
OSV Use	726	2,066	13.3	9.5
Visitor Travel	4.3	35.4	5.4	1.0
Subtotal	730	2,101	18.7	10.5
Year 2020 Total	730	2,101	21.3	10.6
Emissions Source	**2020 Program Growth Pollutant Emissions (tons)**			
	HC	**CO**	**NOx**	**PM**
Direct				
Plowing and Grooming	--	--	3.2	0.15
Indirect				
OSV Use	1,074	3,057	19.6	14.1
Visitor Travel	6.34	52.38	7.98	1.49
Subtotal	1,080	3,109	27.6	15.6
Year 2020 Total	1,080	3,109	30.8	15.8

Source: TRA Environmental Sciences, Inc. 2010; Compiled from Tables 4-11 thru 4-14.

Air Quality Plans

Expanded Trailhead Parking, Increased Grooming at Existing Trails, New Trail Systems. The direct emissions that would occur under the 2020 Program Growth condition (increase of 1,100 grooming hours and 700 snow removal hours) would not conflict with or obstruct an applicable air quality plan since there are no plans in place that directly govern mobile source emissions from the project's snow removal and trail grooming equipment. As described in the Air Quality Plan discussion in Section 4.3.2.1, the snow removal and trail grooming equipment is required to comply with federal and state emissions standards. The project does not involve new land uses, contribute to urban growth, or introduce new stationary sources of air pollutants and would therefore not conflict with an applicable air quality management plan. The direct emissions of the 2020 Program Growth condition are considered to have a less than significant effect on air quality plans.

Growth in OSV Recreation. The indirect OSV use emissions that would occur under the 2020 Program Growth condition would not conflict with or obstruct an applicable air quality plan for the same reasons discussed above under the Direct Emissions analysis. There are no plans that govern OSV user emissions, and the individual emissions produced by each OSV would be required to meet applicable federal and state emissions standards. The indirect OSV use emissions of the 2020 Program Growth condition would have a less than significant effect on air quality plans.

The indirect visitor travel emissions of the 2020 Program Growth condition are part of on-highway vehicle travel growth accounted for in the statewide transportation inventory and in basin attainment plans maintained by the individual air districts. The emissions from passenger trips to the Project Area would have a less than significant effect on air quality plans. .

<u>**Air Quality Standards and Nonattainment Regions**</u>

Expanded Trailhead Parking, Increased Grooming at Existing Trails, New Trail Systems. As described in the Air Quality Standards and Nonattainment Regions analysis in Section 4.3.2.1, the direct emissions under the 2020 Program Growth condition would operate at night and move continually over many miles of trails and roads such that there are no localized concentrations of exhaust emissions. Concentrations of air pollutants from equipment exhaust would low and intermittent during the 14-week winter season (mid-December through March) and would not approach significance levels for diesel particulate matter or ambient air quality standards for other pollutants.

With the exception of Lassen County APCD and parts of Northern Sierra AQMD and Great Basin Unified APCD, air districts within the Project Area are in non-attainment for state ozone standards. The regional impact of ozone precursor emissions is minimal during the cold winter season when conditions do not favor formation of ozone. Therefore, the project's direct emissions would have a less than significant effect on ozone contribution in non-attainment air basins in the Project Area.

With the exception of Siskiyou County APCD all of the 10 air districts within the Project Area are in non-attainment with state PM_{10} standards. Project PM_{10} emissions occur in areas remote from other existing sources. Elevated PM_{10} levels in the non-attainment air districts in the Project Area are largely associated with fugitive dust from unpaved surfaces, which are covered by snow during the winter season, or from wood burning in settled areas away from the trail sites. Therefore, project PM_{10} emissions occur when high background PM_{10} levels are not present. For these reasons, the Project is not likely to violate air quality standards or contribute significantly to PM_{10} or levels in non-attainment regions. The Lake Tahoe air basin is known to have elevated PM_{10} levels during the winter season; however, the OSV Program supported trail systems and trailheads are located outside of this sensitive air basin.

Growth in OSV Recreation. The 2020 Program Growth conditions would increase OSV ozone precursor emissions throughout the Project Area. As described in the Air Quality Standards and Nonattainment Regions analysis in Section 4.3.2.1, OSVs are classified as OHVs and are included in the emission inventories prepared by each air district. For example, the Northern Sacramento Valley Planning Area 2009 Triennial Air Quality Attainment Plan emission inventory lists baseline 2008 OHV recreation vehicle emissions as approximately 2.9 tons per day and expects growth in Year 2020 to reach 3.3 tons per day, a 16% increase (SVAQEEP 2009).

With the exception of Lassen County APCD and parts of Northern Sierra AQMD and Great Basin Unified APCD, air districts within the Project Area are in non-attainment for state ozone standards. The indirect OSV use Program Growth condition ROG and NOx emissions would be spread out over many miles of trails. These emissions would occur intermittently from December to March, when low temperatures, low sunlight conditions, and short duration days reduce the potential for ozone formation. Therefore, the project's indirect OSV emissions would have a less than significant effect on ozone contribution in non-attainment air basins in the Project Area.

Similarly, the project's indirect PM_{10} emissions would occur when high background PM_{10} levels are not present. For this reasons, the Project's indirect OSV emissions are not likely to violate air quality standards or contribute significantly to PM_{10} or levels in non-attainment regions. The Lake Tahoe air basin is known to have elevated PM_{10} levels during the winter season; however, the OSV Program supported trail systems and trailheads are located outside of this sensitive air basin.

As described under the Air Quality Standards and Nonattainment Regions analysis in section 4.3.2.1, indirect emissions from passenger vehicles traveling to and from the Project Area associated with OSV recreation are part of the on-road motor vehicle emissions planned for by the individual air districts. The air quality effects of these indirect project emissions are determined to be less than significant.

Sensitive Receptors and Odors

Expanded Trailhead Parking, Increased Grooming at Existing Trails, New Trail Systems. As described under the Sensitive Receptors and Odors analysis in Section 4.3.2.1, there are no sensitive receptor locations adjacent to the trailheads or groomed trail systems. The exposure of sensitive receptors to substantial pollutants and odors from direct project emissions is considered less than significant.

Growth in OSV Recreation. As described under the Project Baseline condition analysis, the Project would not expose sensitive receptors to substantial concentrations, or create objectionable odors affecting a substantial number of people. Potential odors associated with OSV use would be voluntary, short term (a few hours), and intermittent; passenger vehicles travelling to the Project Area would not expose sensitive receptors to substantial pollutant concentrations or odors from indirect project emissions. The project effect is less than significant.

4.3.2.3 Cumulative Impacts

Air quality is a regional and statewide issue. The Project would generate air pollutant emissions of PM_{10} and NOx in air basins which exceed state standards for these pollutants. The project emissions would occur at a time of year when background PM_{10} levels are low and NOx is less likely to form ozone. Thus, the project's contribution to air quality issues within local air basins is considered minimal and would not contribute to cumulative significant effects. No new land use activities within the national forests are proposed that would add PM_{10} and NOx emissions to pollutant concentrations in the Project Area when project emissions are occurring. There are no other stationary source projects proposed in the Project Area identified by the national forests (Appendix G) that would contribute new sources of emissions in addition to the continuation of the OSV Program. One special event, the Turning Point Snowmobile Rally fundraiser, is proposed for February 2011 at the Little Truckee Summit and Jackson Meadows area (Tahoe National Forest; Appendix G). The event would attract up to 160 participants over one 8-hour day. Although this event would contribute additional PM_{10} and NOx emissions, given the very short-term nature of the event, its location, and the timing (winter), it would not combine with the Project to produce significant cumulative air quality impacts. Other mobile sources of emissions occurring in the Project Area such as vehicle travel along project access roads or Caltrans plowing along highways near project trailheads are part of existing baseline conditions and their growth is planned and accounted for in the emission inventories maintained by each air district. Therefore, there are no cumulative air quality impacts associated with this Project.

4.3.3 Energy Use

4.3.3.1 Project Baseline, Year 2010

Project Energy Use

Direct Energy Use: Snow Removal and Trail Grooming. Direct project energy use is roughly 59,000 gallons per year of diesel in baseline year 2010 (Appendix E, Table AQ-17). Diesel used in large internal combustion engines is extremely efficient. The current program serves some 79,000 visitor vehicle-days (Appendix E, Table AQ-5a), which includes both motorized and non-motorized recreation. With two or three persons per vehicle, the fuel use contributes to support upwards of 200,000 visitor-days of recreation on national forest land.

Indirect Energy Use: OSV Use. Fuel use from on-snow motorized recreation is considerable. The 26 trail systems groomed by the OSV Program comprise a significant proportion of statewide winter OHV recreation (see Recreation, Table 8-2). Supported use is estimated to be approximately 159,000 OSV-days per year (Project Description, Table 2-8). With typical fuel consumption of 8 gallons per OSV-day, annual OSV fuel use is on the order of 1.2 million gallons of gasoline per year (Appendix E, Table AQ-27).

Indirect Energy Use: Passenger Vehicle Travel. User travel to and from the Project Area is estimated to be some 79,000 visitor vehicles traveling a total of 19.5 million miles per year. Currently, light duty trucks and SUV have relatively low fuel economy, assuming 12 miles per gallon, the user travel consumes some 1.6 million gallons of petroleum based motor vehicle fuel per year (Appendix E, Table AQ-13).

Energy Use Impact

<u>**Efficiency of Energy Consumption**</u>

Direct Impact: Snow Removal and Trail Grooming. The project direct energy use from snow removal and trail grooming operations is 59,000 gallons per year at current baseline levels rising to 74,000 gallons of diesel per year over the 10-year program period (Appendix E, Table AQ-27).

As stated above in Section 4.3.1.2, CEQA Guidelines focus the evaluation of energy impacts on whether a Project causes inefficient, wasteful, or unnecessary consumption of energy resources. Fuel consumption associated with the OSV Program is not wasteful or excessive considering the recreational objective achieved (Project Description, Section 2.2). The total fuel consumed by direct project activities of the OSV Program cannot be further reduced beyond the fuel efficiencies gained by the state’s off-road vehicle replacement program described in Project Description, Section 2.4.1 unless the scope of the OSV Program is reduced. The demand for winter trail recreation increases annually, making the energy use expended to provide the recreation opportunity a worthwhile public service. Based on the recreation demand and the state’s management of its off-road vehicle fleet to maximize fuel efficiencies, the direct project activity would not result in inefficient, wasteful, or unnecessary energy consumption. Therefore, the project effect is less than significant.

Indirect Impact: OSV Use and Passenger Vehicle Travel. Indirect energy use is substantial, with OSV use and visitor travel together consuming an estimated 3 million gallons of gasoline and diesel at baseline 2010 levels, possibly 3.4 million gallons per year by 2020 (Appendix E, Tables AQ-12 and AQ-13). However, in the context of state-wide energy use, the indirect fuel use is small: annual consumption of gasoline and diesel motor fuels is roughly 20 billion gallons per year (CEC 2007) and project related use is 0.015 % of that total.

The energy use is part of the energy budget of state residents using OSV Program trail facilities and associated trailheads. Use is upwards of 200,000 visitor-days per year. Statewide resident and non-resident OSV registrations were 22,900 in 2009 (Project Description, Section 2.7.2.1); a 1997 survey found 8,000 families owning the 14,000 OSVs registered that year (1.75 OSV/household), with 72% traveling with four or more people in their typical snowmobile group. This suggests that the current OSV user community in California is roughly 52,000[1] persons, with non-owner guests additional. The OSV Program is a major part of legal, supported OSV recreation in California; it is reasonable to expect that a majority of the OSV community uses OSV Program facilities during some part of the season. Assuming that on average, two-thirds of the community (approximately 35,000) use the facilities yearly, the estimated annual 200,000 user-days means an average of 5.7 use-days per person per year.

Considering the population served, the 2.9 million gallons of indirect fuel use at baseline 2010 levels is 15 gallons per user-day, approximately 85 gallons per person served per year. Indirect fuel use in 2020 could grow to 3.4 million gallons per year if the user population were to grow by 48% to around 300,000 user-days – roughly 12 gallons per user-day.

This fuel use is a result of individuals seeking mountain recreation opportunities remote from the urban population centers. The level of energy use indirectly caused by the Project through OSV use and vehicle travel to the Project Area is not considered inefficient, wasteful, or unnecessary. For this reason, the indirect energy impact of the Project is considered less than significant.

[1] 22,900 registered OSV / 1.75 OSV/household = approximately 13,000 OSV owning households; multiplied times 4 persons per household = 52,000 persons

4.3.3.2 10-Year Program Growth, Year 2020

Project Energy Use

Direct Energy Use: Snow Removal and Trail Grooming. Program growth as described in Project Description, Section 2.7.1, may result in diesel use rising possibly to 74,000 gallons as equipment operation at project locations may increase due to increased demand for winter trail recreation. Future replacement of older equipment would produce improved work efficiency and would somewhat reduce fuel use as well as reduce air pollutant emissions.

Indirect Energy Use: OSV Use. Over the 10-year program period, future OSV use may increase (Project Description, Section 2.7.2). As discussed in Section 4.3.2.2, OSV emissions standards would come into effect resulting in an increased efficiency for two-stroke designs and a greater proportion of four-stroke engines in the vehicle fleet in use. Design improvements to reduce emissions would also improve fuel efficiency. The average four-stroke OSV uses 0.648 pounds of gasoline to generate one brake horsepower-hour (bhp-hr) of work, compared with 1.08 pounds used by a two-stroke engine. Note that two-stroke air pollutant HC and CO emissions are unburned or incompletely burned fuel with concomitant loss of energy value. Two-stroke HC emissions are 140 grams per bhp-hr (Lela and White 2002, Appendix E, Table AQ-1), which means that nearly 30% of a gallon of gasoline is wasted in the exhaust of a conventional two-stroke snowmobile. The estimated improvement in OSV emissions would also serve to improve fuel consumption. Project year 2020 estimates have a 48% increase in OSV recreation use with only a 28% increase in fuel use to roughly 1.6 million gallons per year as compared to Project Baseline 2010 conditions (Appendix E, Table AQ-27).

Indirect Energy Use: Passenger Vehicle Travel. Possible increased demand for OSV recreation would result in increased travel by passenger vehicles. Anticipated federal fuel efficiency standards may produce a general 25% reduction in fuel consumption for pick-up trucks and SUVs, which would offset some of the effect of increased travel. Social trends over the past decade due to higher fuel costs and energy awareness have produce a small reduction in voluntary fuel use for recreation and holiday travel; this is not factored into the estimate. Project-year 2020 indirect transportation fuel use would be on the order of 1.8 million gallons (Appendix E, Table AQ-13).

Energy Use Impact

<u>**Efficiency of Energy Consumption**</u>

Expanded Trailhead Parking, Increased Grooming at Existing Trails, New Trail Systems. See Energy Use Impact discussion in Section 4.3.3.1 above. Given the increased demand for OSV recreation in conjunction with the increased energy efficiency of the motorized equipment (grooming/plowing), the level of energy use from project equipment is not considered inefficient, wasteful, or unnecessary. For this reason, the energy use impact of the Project is considered less than significant.

Growth in OSV Recreation. See Energy Use Impact discussion in Section 4.3.3.1 above. Given the increased demand for OSV recreation in conjunction with the increased energy efficiency of the motorized equipment associated with OSV recreation (OSVs and transport vehicles), the level of energy use from these indirect project sources is not considered inefficient, wasteful, or unnecessary. For this reason, the energy use impact of the Project is considered less than significant.

4.3.3.3 Cumulative Impacts

California's population is forecast to grow from almost 39 million people in 2010 to 44 million in 2020 (Dept. of Finance 2007, 2010). As noted in Section 10.2.3, the Project would contribute to California's consumption of non-renewable fossil fuels. Fossil fuels would be required for grooming and plowing equipment, OSVs, and for the vehicles transporting OSV recreationists to the trailheads. The OSV recreation described in this EIR, however, will be just one small part of the energy demands of California's large and growing population (see, e.g., Sections 4.2.3 and 4.3.3.1), and the equipment involved is subject to state and federal emissions and fuel economy standards. Section 10.2.3 further notes that the Legislature has recognized the popularity of OHV recreation and charged the OHMVR Division with supporting both motorized recreation and motorized off-highway access to nonmotorized recreation. Considering this statutory mandate to support OHV recreation, the Project's contribution to cumulative energy consumption in California would not be inefficient, wasteful, or unnecessary.

4.3.4 Greenhouse Gases

4.3.4.1 Project Baseline, Year 2010

Project Emissions

Direct Emissions: Snow Removal and Trail Grooming. The State of California is now undertaking planning for implementing the objectives of the California Global Warming Solutions Act of 2006 (AB32), which requires a statewide reduction of GHG emissions to year 1990 levels by year 2020. Such statewide measures would apply to the direct and indirect emissions from the OSV Program.

Diesel combustion from direct project fuel use generates NOx, as discussed above in Section 4.3.2.1, and essentially all of the carbon in the fuel is converted to CO_2. Because combustion adds the mass of combined oxygen to the carbon, one pound of hydrocarbon fuel produces 3.14 pounds of CO_2; diesel has a fuel density of 7.1 pounds per gallon, resulting in approximately 22.3 lbs of CO_2 per gallon of diesel fuel. NOx has the potential to be converted toN_2O which has a greenhouse warming potential greater than CO_2 alone. The NOx component of transportation emissions contribute an additional 4.7% CO_2 equivalent as N_2O (based on similar calculation from Staff Report California 1990 Greenhouse Gas Emissions Level and 2020 Emissions Limit 11/16/2007).

Direct GHG emissions are estimated as 626 $MTCO_2e$ per year in baseline year 2010 (Table 4-16), rising to 822 MTCO2e in 2020 (Table 4-17; see Section 4.3.4.3 below). These levels are below all preliminary quantitative thresholds of significance in GHG plans now under consideration around the state described in Section 4.3.1.

Indirect Emissions: OSV Use and Passenger Vehicle Travel. Indirect OSV and transportation fuel use are described above in Energy Use, Section 4.3.3. Fuel use from on-snow motorized recreation and from user vehicle travel to and from trailheads is considerable. Cumulatively, they contribute nearly 50 times more GHG than do direct project emissions. Table 4-16 shows baseline 2010 GHG emission from direct and indirect sources.

The OSV Program trail systems provided in the Project Area comprise a significant proportion of the statewide winter OHV recreation opportunity (see Recreation, Table 8-2). Supported OSV use is estimated to be approximately 159,000 OSV-days (Project Description, Table 2-8) and the project trailheads and additional parking areas serve upwards of 200,000 visitor-days per year for motorized and non-motorized recreation (Project Description, Section 2.6.1.2). Transportation to trailheads from home or local accommodation and return is estimated to be 19.4 million vehicle miles per year. OSV fuel use and vehicle travel consume petroleum based fuel and generate GHG emissions, mainly as CO_2.

In the baseline year 2010, total project direct and indirect GHG emissions are estimated at 27,118 $MTCO_2e$. In context, the baseline emissions contribute 0.0056% of the latest state-wide inventory (2006) and 0.163 $MTCO_2e$ per OSV use-day.

Table 4-16. 2010 Project Baseline Annual Greenhouse Gases, All Sources

Source	Fuel Use (gallons)	$MTCO_2$	MTN_2O	ALL GHG $MTCO_2e$
Grooming and Plowing	58,802	598	28	626
OSV Use	1,249,586	10,996	512	11,508
User Transportation	1,627,065	14,318	666	14,984
Total	2,935,452	25,913	1,206	27,118
Total as % of current statewide GHG inventory				0.0057%

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Table AQ-27

Greenhouse Gases Impact

<u>Greenhouse Gas Emissions Levels and Greenhouse Gas Reduction Plans</u>

Direct Emissions: Snow Removal and Trail Grooming. Air pollutant emissions reductions would have a small, but meaningful benefit to GHG emissions because the NOx component and N_2O contribution would be cut sharply. Overall, there may some increased efficiency in future equipment use as well which could reduce hours of equipment operation and fuel consumption thereby further reducing pollutant and GHG emissions. Those factors have not been quantified and are not included in GHG estimates for 2020.

Although there is no specific GHG plan that applies to OSV Program direct emissions, the relatively small level of emissions compared to the GHG thresholds being considered elsewhere (see section 4.3.1) lead to a conclusion that the direct GHG impact is less than significant.

Indirect Emissions: OSV Use and Passenger Vehicle Travel. Baseline emissions from OSV use and visitor travel to and from the Project Area are not new emissions but rather a continuation of current conditions. Although these current conditions are contributing toward the statewide exceedance of the GHG emissions levels in excess of the 1990 rollback goal specified for the state, the impact is not considered significant as it is not a net increase above the current baseline and is not a net increase in GHG.

4.3.4.2 10-Year Program Growth, Year 2020

Project Emissions

Direct Emissions: Snow Removal and Trail Grooming. Future GHG levels associated with direct project emissions under the 10-year program growth scenario are projected to rise to from 626 MT to 786 MT in 2020 (Table 4-17). Actual future levels may be less as recreational use demand may increase less than predicted and as climate change may shorten the snow season reducing the need for grooming or snow removal services. The predicted near-term effect of climate change would be a 25% reduction in Sierra snowpack by 2050 (DWR 2007). This estimate is mainly aimed at predicting future water availability, but also suggests that snow-based recreation would be curtailed as well and the trend may be experienced over the 10-year program period. Reduced snowpack would mean a shorter season and less snow at lower elevation trails, which would also reduce demand for grooming equipment operations.

Table 4-17. 2020 Program Growth Annual Greenhouse Gases, All Sources

Source	Fuel Use (gallons)	MT CO2	MT N2O	ALL GHG MT CO2e	As % of Baseline 2010
Grooming and Plowing	73,871	751	35	786	126%
OSV Use	1,578,745	13,893	646	14,539	126%
User Transportation	1,818,082	15,999	744	16,744	112%
Total	3,470,698	30,643	1,426	32,069	118%
Total as % of statewide GHG target 1990 inventory				0.0064%	

Source: TRA Environmental Sciences, Inc. 2010; Appendix E Table AQ-27

Indirect Emissions: OSV Use and Passenger Vehicle Travel. The project anticipates possible program growth to accommodate increased demand for winter trail recreation. As described in Project Description, Section 2.7, there could be a 48% increase in OSV use over the next ten years with a proportionate increase in visitor transportation. Table 4-17 shows projections for GHG emissions in 2020. Some improvements in both OSV and transport fuel efficiency would reduce overall GHG increase to an estimated 20%, so that GHG emissions per OSV use-day fall from 0.163 to 0.130 $MTCO_2e$ (Appendix E, Table AQ-27).

Greenhouse Gases Impact

The Year 2020 Program Growth condition results in an increase of 4,951 MTCO2e above baseline conditions (Table 4-16 and Table 4-17). This section analyzes the significance of this GHG emissions increase.

<u>Greenhouse Gas Emissions Levels and Greenhouse Gas Reduction Plans</u>

Expanded Trailhead Parking, Increased Grooming at Existing Trails, New Trail Systems. The increase of 160 $MTCO_2e$ from direct project emissions under the 10-year growth scenario (increase of 1,100 grooming hours and 700 plowing hours) is a 26% increase over 2010 baseline conditions (Table 4-16 and Table 4-17). This level remains below all preliminary quantitative thresholds of significance in GHG plans now under consideration around the state described in Section 4.3.1. Therefore, the direct GHG impact under the program growth scenario is less than significant.

Growth in OSV Recreation. The increase of 4,791 MTCO2e from indirect project emissions from OSV use and passenger vehicle travel (Table 4-16 and Table 4-17) could conflict with the state goal to roll back GHG emissions to 1990 GHG levels of 427 MMTCO$_2$e. With a "business-as-usual" approach, CARB forecasts the statewide GHG emissions will rise to 596.4 MMT. Although the OHMVR Division has not adopted its own quantitative standards of significance for GHG emissions and potential global climate change impacts, the state goal of a roll-back to 1990 GHG emissions levels is a quantitative target.

As identified in Section 4.3.1.3 above, several air districts have developed numerical GHG emission thresholds of significance. While these thresholds do not apply to this statewide activity, they can be used to provide an indication of a consequential GHG contribution and serve as a benchmark for determining significance of GHG emissions.

Overall projected growth of the OSV Program by 2020 would increase GHG emissions from 27,118 MTCO$_2$e (2010) to 32,069 MTCO$_2$e (2020) resulting in a net increase of 4,951 MTCO$_2$e. This increase is more than the BAAQMD land use project threshold of 1,100 MTCO$_2$e and the SCAQMD residential/commercial project threshold of 3,000 MTCO$_2$e, but less than 10,000 MTCO$_2$e stationary source level that both the SCAQMD and BAAQMD have established for stationary source projects. These thresholds, however, are not applicable to a state-wide recreational project such as the OSV Program.

The BAAQMD has also developed an efficiency-based threshold of 4.6 MTCO$_2$e per service population per year that is meant to allow efficient projects with higher mass emissions to meet the overall GHG reduction goals of AB32. The 4.6 MTCO$_2$e per service population per year was derived from CARB's AB32 GHG inventory and estimates of California's Year 2020 service population (population + employment) and is an estimate of the amount of land-use related GHG emissions that each state resident and employee could emit in Year 2020 without impeding the GHG reduction goals of AB32. The OSV Program is a state-wide recreational project that produces GHG from mobile sources that are not under the permitting control of any one air district and therefore an efficiency based threshold, which normalizes GHG emissions for project size, provides the most appropriate benchmark for considering the significance of the project's GHG emissions. Under the Year 2020 Program Growth condition, the Project would accommodate approximately 300,000 visitors and produce approximately 32,069 MTCO$_2$e, or 0.11 MTCO$_2$e per visitor which is considerably small in comparison to the 4.6 MTCO$_2$e per capita threshold.

There are currently no plans which specifically address recreational fuel use. Several statewide plans address transportation fuel use and GHG emissions generally. The OSV Program is not specifically in conflict with these plans as it does not impede their implementation.

The Year 2020 Program Growth condition would result in direct and indirect GHG emissions that would not exceed the efficiency metric threshold established by the BAAQMD nor impede the GHG reduction goals of AB32. The individual on and off-road equipment that produces these emissions would be subject to voluntary and regulatory actions developed under AB32 and would not conflict with any GHG reduction plan. The project's effect on GHG emissions is considered less than significant.

4.3.4.3 Cumulative Impacts

The Project, by nature of location and purpose, supports consumption of fossil fuel resulting in GHG emissions. Growth in the OSV Program operation and in OSV use of the trail systems above existing levels would create new GHG emissions statewide. General population growth and development throughout the state will add to GHG emissions in the state above existing inventory levels. Increases in the state GHG inventory conflict with the state goal of reducing the GHG inventory back to the 1990 level. Analysis of a project's GHG emission contribution is an assessment of a project's cumulative impact on state-wide emission levels. There are no GHG standards that apply to statewide motorized recreation. Based on comparison to standards that are most closely relevant, the project's cumulative GHG emission level is less than significant.

4.4 MITIGATION MEASURES

The above analysis identifies that direct and indirect emissions associated with the Project Baseline and Program Growth conditions would not result in any individual or cumulatively significant impacts. The on- and off-road equipment that generates project emissions would be subject to federal and state emission standards and regulations that control and reduce project emissions. No additional mitigation measures are necessary for the project.

GHG emissions can be further reduced only by reducing the level of service and hence fuel use. Alternate fuels for grooming and plowing equipment are not likely to be available in the ten year time frame of the Project. There are no commercially available substitutes for diesel in heavy duty, mobile applications. Biodiesel has a slightly smaller net GHG emission per gallon than petroleum-based diesel. At present, biodiesel is not a viable substitute for petroleum diesel as the slightly different chemical composition makes biodiesel more likely to gel at lower temperatures. Winter operations in remote, rural locations are not a prime candidate for biodiesel and its use is not recommended by this EIR. Several state and federal programs, mainly improved fuel efficiency, would reduce the unit GHG emissions from OSV recreation measured in pounds per person served by an estimated 23%. California's Low Carbon Fuel Standard will also serve to reduce the carbon content in transportation fuels by 10% by Year 2020, further reducing GHG emissions. No additional mitigation measures are necessary for the Project.

5.0 BIOLOGICAL RESOURCES

This chapter describes the potential effects of OSV Program activities on biological resources, including vegetation communities, wildlife, and special-status species. The assessment is based on USFS monitoring information, CDFG resources such as the California Natural Diversity Database (CNDDB), and review of the scientific literature on species' life histories, distribution, habitat requirements for breeding and forage, response to human disturbance, and current threats. It addresses the impacts of maintaining trailheads, trails, and access roads as well as OSV use in the surrounding areas both on and off-trail.

5.1 REGULATORY SETTING

5.1.1 Federal

5.1.1.1 Federal Endangered Species Act

The federal Endangered Species Act (ESA) of 1973 (16 USC §§ 1531 et seq.) protects fish and wildlife species that are listed as threatened or endangered, and their habitats. "Endangered" refers to species, subspecies, or distinct population segments that are in danger of extinction in all or a significant portion of their range. "Threatened" refers to species, subspecies, or distinct population segments that are considered likely to become endangered in the future.

Federal ESA Section 9 protects federally listed endangered and threatened wildlife species from unlawful take (16 U.S.C. § 1538 (a)(1)). "Take" is defined to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S.C. § 1532 (19)). "Harm" is defined as an act that "actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering" (50 CFR 17.3). The ESA also prohibits removing, digging up, cutting, or maliciously damaging or destroying federally listed plants on federal land.

Section 7 of the ESA requires federal agencies, in consultation with and with the assistance of, the Secretary of the Interior or the Secretary of Commerce, as appropriate, to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of threatened or endangered species or result in the destruction or adverse modifications of critical habitat for these species. Critical habitat is defined as specific geographic areas, whether occupied by listed species or not, that are determined to be essential for the conservation and management of listed species, and that have been formally described in the Federal Register. Section 10 of the ESA provides a means whereby a nonfederal action with a potential to result in the take of a listed species could be allowed under an incidental take permit. An incidental take permit is required when non-federal activities would potentially result in the take of a threatened or endangered species.

Under the ESA, the Secretary of the Interior and the Secretary of Commerce have the authority to list species as threatened or endangered. The ESA is enforced by the USFWS and National Marine Fisheries Service (NMFS). NMFS's jurisdiction under ESA is limited to the protection of marine mammals, marine fishes, and anadromous fishes; all other species are subject to USFWS jurisdiction. The USFWS also publishes a list of candidate species. Species on this list receive "special attention" from federal agencies during environmental review, although they are not protected otherwise under the ESA. The candidate species are those for which the USFWS has sufficient biological information to support a proposal to list as endangered or threatened.

The USFWS no longer maintains a species of concern list; however, in compliance with the Fish and Wildlife Conservation Act (1980, as amended), the USFWS has identified "species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act of 1973." Birds of Conservation Concern 2002 is a compilation of information about bird species of concern that identifies which species are of concern in each region of the country. The OSV Program Project Area is within Bird Conservation Regions 15 (Sierra Nevada) and 9 (Great Basin). NMFS does maintain a species of concern list. For NMFS, species of concern are those species that it has some concerns about, but for which insufficient information is available to indicate a need to list the species under the ESA. Thus, "species of concern" are not regulated by the ESA, and take of a species of concern is not prohibited by the ESA and does not require a take permit.

5.1.1.2 Migratory Bird Treaty Act

The federal Migratory Bird Treaty Act (MBTA) (16 USC §§ 703 et seq.) enacted the provisions of treaties between the United States, United Kingdom, Mexico, Japan, and the Soviet Union, and authorizes the Secretary of the Interior to protect and regulate take of migratory birds. The MBTA is administered by the USFWS. It establishes seasons and bag limits for hunted species, and renders taking, possession, import, export, transport, sale, purchase, and barter of migratory birds, their occupied nests, and their eggs illegal except when authorized by a federal permit. Take is defined more narrowly under the MBTA than under the ESA and includes only the death or injury of individuals of a migratory bird species or their eggs. As such, take under the MBTA does not include the concepts of harm and harassment as defined under the ESA.

More than 800 species of birds are protected under the MBTA. Specific definitions of migratory bird are addressed in the international treaties. In general, birds that migrate to complete different stages of their life history or to take advantage of different habitat opportunities during different seasons are "migratory birds" subject to the MBTA.

5.1.1.3 Bald and Golden Eagle Protection Act

The federal Bald and Golden Eagle Protection Act (16 USC §§668 et seq.) makes it unlawful to import, export, take, sell, purchase, or barter any bald eagle or golden eagle, or their parts, products, nests, or eggs. "Take" includes pursuing, shooting, poisoning, wounding, killing, capturing, trapping, collecting, molesting, or disturbing. Exceptions may be granted by the USFWS for scientific or exhibition use, and for cultural use by Native Americans; however, no permits may be issued for import, export, or commercial activities involving eagles.

5.1.1.4 Federal Code of Regulations: Forest Service Management Plans, Forest Service Sensitive Species

Each national forest has a LRMP (see Land Use Plans and Policies, Section 4.0) that provides S&Gs for managing each national forest's resources. The purpose of these LRMPs is to guide efficient use and protection of forest resources, fulfill legislative requirements, and balance local, regional, and national needs. The LRMPs emphasize the maintenance or improvement of endangered, threatened, and sensitive species habitat, and game species habitat. The S&Gs provide direction for managing sensitive species and their habitats.

Forest Service Sensitive (FSS) species are species identified by the Regional Forester for which population viability is a concern as defined in the Forest Service Manual Chapter 2670. The USFS develops and implements management practices to ensure that plants and animals do not become threatened or endangered and to ensure their continued viability on national forests. It is USFS policy to analyze impacts to FSS species to ensure forest management does not cause a significant trend toward federal listing or loss of viability.

The SNFPA of January 2004 (see Land Use Plans and Policies, section 3.1.2) provides S&Gs for species protection where OSV recreation disturbance was identified as a risk factor affecting species viability. By adhering to the SNFPA and implementing the protection measures identified in the S&Gs, the national forests maintain population viability by minimizing resource conflict as discussed in the SNFPA.

Each of the 11 national forests within the Project Area has a forest plan (LRMP) designating areas as open, restricted, or closed to OSV use. OHV travel is managed in accordance with Executive Order (EO) 11644, as amended by EO 11989, and the Code of Federal Regulations 212, 219, 261 and 295 (CFR). The land management planning process is used to allow, restrict, or prohibit use by specific vehicle types off-highway. During the planning process, OSV effects on soil, water, vegetation, fish, wildlife, forest visitors, as well as cultural and historic resources must be analyzed (36 CFR 219.21(g) and 295.2(a). OSV use is prohibited in areas classified as wilderness, primitive, or semi-primitive non-motorized. Under EO 11644, as amended by EO 11989, seasonal closures and designated trails may be used to mitigate impacts from OSV use. The USFS Management Actions protecting special-status species in the national forests within the Project Area are summarized in Table 5-3 and Table 5-5.

5.1.2 State

5.1.2.1 California Endangered Species Act

The California Endangered Species Act (CESA), which is administered by CDFG, protects wildlife and plants listed as “threatened” or “endangered” by the California Fish and Game Commission, as well as species identified as candidates for listing. The CESA restricts all persons from taking listed species except under certain circumstances. The state definition of take is similar to the federal definition, except that the CESA does not prohibit indirect harm to listed species by way of habitat modification. Under the CESA, an action must have a direct, demonstrable detrimental effect on individuals of the species. Under Sections 2080 and 2081 of the California Fish and Game Code, the CDFG may authorize take of listed species, except for species that are designated as fully protected. Fully protected species may not be taken except for scientific research. Various Fish and Game Code sections identify fully protected species.

CDFG maintains lists of animal species of special concern (CSSC) that serve as "watch lists." A CSSC is not subject to the take prohibitions of the CESA. The CSSC are species that are declining at a rate that could result in listing under the ESA or CESA and/or have historically occurred in low numbers, and known threats to their persistence currently exist. This designation is intended to result in special consideration for these animals and is intended to focus attention on the species to help avert the need for costly listing under federal and state endangered species laws. This designation also is intended to stimulate collection of additional information on the biology, distribution, and status of poorly known at-risk species, and focus research and management attention on them (CDFG 2003).

State agencies should not approve projects as proposed which would jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat essential to the continued existence of those species, if there are reasonable and prudent alternatives available consistent with conserving the species or its habitat which would prevent jeopardy (Fish and Game Code § 2053). Incidental take of species listed under CESA may be permitted under Sections 2080.1 or 2081(b) of the California Fish and Game Code.

5.1.2.2 California Fish and Game Code

The California Fish and Game Code protects a variety of species, separate from the protection afforded under the CESA. The following specific statutes afford some limits on take of named species: Section 3503 (nests or eggs), 3503.5 (raptors and their nests and eggs), 3505 (egrets, osprey, and other specified birds), 3508 (game birds), 3511 (fully protected birds), 4700 (fully protected mammals), 4800 et seq. (mountain lions), 5050 (fully protected reptiles and amphibians), and 5515 (fully protected fish).

Section 3503 simply states, “it is unlawful to take, possess, or needlessly destroy the nest or eggs of any bird, except as otherwise provided by this code or any regulation made pursuant thereto.” The exceptions generally apply to species that are causing economic hardship to an industry. Section 3503.5 states that it is "unlawful to take, possess, or destroy any birds in the order Falconiformes or Strigiformes (birds of prey) or to take, possess, or destroy the nest or eggs of any such bird except as otherwise provided by this code or any regulation adopted.” Section 3505 prohibits taking, selling, or purchasing egrets, osprey, and other named species or any part of such birds.

The mountain lion is a “specially protected” species under Sections 4800 et seq. of the Fish and Game Code. It is unlawful to take mountain lion except in instances and methods allowed in the Fish and Game Code.

Certain species are also fully protected. This classification was the state's initial effort in the 1960's to identify and provide additional protection to those animals that were rare or faced possible extinction. Lists were created for fish, amphibians and reptiles, birds, and mammals. Most fully protected species have also been listed as threatened or endangered species under the more recent endangered species laws and regulations. Fully protected species may not be taken or possessed at any time, and no licenses or permits may be issued for their take except for collecting these species for necessary scientific research or for habitat restoration that will promote their survival.

5.1.2.3 California Native Plant Protection Act

The California Native Plant Protection Act (CNPPA) of 1977 preserves, protects, and enhances endangered and rare plants in California by specifically prohibiting the importation, take, possession, or sale of any native plant designated by the California Fish and Game Commission as rare or endangered, except under specific circumstances identified in the Act. Various activities are exempt from the CNPPA, although take as a result of these activities may require other authorization from CDFG under the California Fish and Game Code.

5.1.2.4 CDFG and the California Environmental Quality Act

As a trustee agency, CDFG comments on the biological impacts of development projects reviewed under CEQA. CEQA gives CDFG jurisdiction to comment on the protection of habitats deemed necessary for any species to survive in self-sustaining numbers, but does not allow CDFG to govern land use. It stipulates that the state lead agency shall consult with, and obtain written findings from, CDFG in preparing an environmental impact report on a project, as to the impact of the project on the continued existence of any endangered species or threatened species (Public Resources Code § 21104.2). A CEQA analysis must consider species presumed to be endangered, rare, or threatened (special-status species). The special-status species considered by this EIR are discussed in Section 5.2.7. CDFG does not have permit authority over a project unless the project would cause take of a state listed species.

5.2 ENVIRONMENTAL SETTING

5.2.1 Regional Setting

The OSV Program is located in 11 of the 18 national forests in the USFS Pacific Southwest Region (Region 5). The Klamath, Shasta-Trinity, Lassen, and Modoc National Forests are located in the southern end of the Cascade Range (Cascades), formed primarily by volcanic action. The Plumas, Tahoe, Eldorado, Stanislaus, Sierra, Inyo, and Sequoia National Forests are in the Sierra Nevada Range (Sierra Nevada), formed primarily by earth and glacial movements. The geologic formation of these ranges affects their biology. The biotic zones in these national forests include lower montane forest, upper montane forest, subalpine forest, and alpine forest.

Weather and altitude influence the biotic zones. During the fall, winter, and spring, precipitation in the Sierra Nevada ranges from 20 to 80 inches where it occurs mostly as snow above 6,000 feet. Summers are dry with low humidity; however, afternoon thunderstorms are common. The growing season ranges from 20 to 230 days, depending on elevation. The Cascades have a similar weather pattern, and receive 20 to 80 inches of precipitation per year with the growing season lasting 30 to 200 days, depending on elevation.

Due to the extremes in topography, large elevation gradient (3,000 to 12,500 feet), and varied climate of the Sierra Nevada and Cascades, the region supports a diverse assemblage of plant species. Fifty percent of California’s 7,000 vascular plants are found in the region and more than 400 plant species are endemic (U.C. Davis 2006). The various climatic conditions and diverse plant communities provide for a large array of habitats.

About 40 percent of the state’s surface water runoff flows to the Central Valley from the Cascades and Sierra Nevada. In the Sierra Nevada, the rivers flow west from the crest in deeply incised canyons to the Central Valley and Pacific Ocean. Rivers flowing east from the Sierra crest end in the Mojave Desert, Mono Basin, or northwestern ranges. Numerous lakes and wet meadows are associated with glaciated areas above 5,000 feet. Project Area streams in the southern Cascades flow west to the Klamath and Sacramento Rivers or east to basins in the Modoc Plateau. The Modoc Plateau region lies to the east in the rain shadow of the Cascades. Modoc National Forest covers part of the Cascades as well as part of the Modoc Plateau; only the Cascades portion of the Modoc National Forest is within the Project Area.

5.2.2 Biological Study Area

The area of biological resources (Biological Study Area [BSA]) evaluated in the OSV Program impact analysis, encompasses a broader area than just the immediate vicinity of trailheads, groomed trails, and open riding areas. The reasons are twofold. Biological resources are dynamic, and it is important to know if sensitive resources occur near the Project Area in surrounding habitat areas and therefore could potentially occur within the Project Area or could be indirectly affected by project activities (e.g., downstream effects). Additionally, OSV use is allowed off trail and extends into the surrounding habitat. It is assumed that most off-trail impact from snow recreation activities would occur within a five-mile radius of the groomed trails due to the presence of physical barriers such as highways, river canyons, excessively steep terrain, thick vegetation, and restricted areas; therefore, this five-mile radius beyond the groomed trail system comprises the Biological Study Area assessed in the biological impact analysis. The biological setting in this EIR provides the regional context for the analysis to cover this broader area.

5.2.3 Vegetation Communities

Vegetation communities (Figure 36) are defined by species composition and relative abundance. Project activities could occur between 4,000 and 10,000 feet above sea level, within the lower montane, upper montane, and the lower elevations of subalpine forest biotic zones. The biotic zones within the Project Area are listed in Table 5-1.

Table 5-1. Biotic Zones Within the Project Area

National Forest	Trail Elevations (feet above sea level)	Biotic Zone(s)
Klamath	5,400-7,400	Lower and upper montane
Modoc	5,500-7,100	Lower and upper montane
Shasta-Trinity	4,100-6,600	Lower montane
Lassen	4,600-7,700	Lower and upper montane
Plumas	4,900-7,300	Lower and upper montane
Tahoe	5,000-7,800	Lower and upper montane
Eldorado	5,700-8,000	Lower and upper montane
Stanislaus	5,900-8,700	Lower and upper montane
Inyo	7,300-9,100	Upper montane and subalpine
Sierra	4,900-9,100	Lower and upper montane, subalpine
Sequoia	5,400-10,000	Lower and upper montane, subalpine

Source: TRA Environmental Sciences, Inc. 2010

The dominant vegetation types in the lower and upper montane are mixed conifer forests of pine, pine-fir, or fir, with total vegetative cover averaging 70 to 100 percent (Fites-Kaufman et al. 2007). Other common vegetation types include sagebrush scrub, pinyon-juniper, and riparian. Less common vegetation types include vernal pools and serpentine soil-based grassland, chaparral, woodland, and forest.

In the lower montane, dominant tree species up to 6000 feet include ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor* var. *Iowiana*), incense-cedar (*Calocedrus decurrens*), Jeffrey pine (*Pinus jeffreyi*), sugar pine (*Pinus lambertiana*) (Fites-Kaufman et al. 2007) and broadleaf upland forest species such as black oak (*Quercus kelloggii*) and bigleaf maple (*Acer macrophyllum*). In ponderosa pine forests, common shrubs include serviceberry (*Amelanchier alnifolia*), wedgeleaf ceanothus (*Ceanothus cuneatus*), mountain misery (*Chamaebatia foliolosa*), and greenleaf manzanita (*Arctostaphylos patula*) (Sawyer et al. 2009). The herbaceous layer is often sparse. In Douglas fir-mixed conifer forests, shrubs may include Oregon grape (*Berberis nervosa*), creeping snowberry (*Symphoricarpos mollis*), and hazel (*Corylus cornuta*) (Sawyer et al. 2009). The giant sequoia (*Sequoiadendron giganteum*) groves in the southen end of the Sierra Nevada are found within the lower montane zone. Non-forested land in the lower montane is typically restricted to rock outcrops or sites where timber has been harvested. Meadows and other herbaceaous-dominated sites, including riparian, are limited in distribution.

The upper montane (typically above 6,000 feet) contains a mosaic of conifer forest, montane meadows, and California montane chaparral. Red fir (*Abies magnifica*), Jeffrey pine, and lodgepole pine (*Pinus contorta* subsp. *murrayana*) are the dominant forest species. Red fir, Jeffrey pine, and lodgepole pine may be the sole species in a canopy or the dominant tree with various other species present. White fir often broadly overlaps with these species and can become dominant between 6,000 and 7,200 feet; often including associations with sugar pine and incense cedar. Shrub cover in white fir forests varies considerably but typically includes mountain pink currant (*Ribes nevadense*), Sierra gooseberry (*Ribes roezlii*), thimbleberry (*Rubus parviflorus*), Sitka willow (*Salix sitchensis*), and blue elderberry (*Sambucus caerulea*) (Sawyer et al. 2009). Co-occurring species include mountain hemlock (*Tsuga mertensiana*), sugar pine, western white pine (*Pinus monticola*), foxtail pine (*Pinus balfouriana*), huckleberry oak (*Quercus vaccinifolia*), pinemat manzanita (*Arctostaphylos nevadensis*), thinleaf huckleberry (*Vaccinium membranaceum*), and bush chinquapin (*Chrysolepis sempervirens*) (Sawyer et al. 2009). Species found within montane meadows are numerous and varied, and may include grasses and forbs as well as woody vegetation. The meadows may be dry or wet. Wet meadows are located in areas where the water table is shallow, creating wet soil conditions year round that exclude conifers and support a high diversity of herbaceous vegetation. Dry meadows generally contain no standing water and are composed of dryland sedges (*Carex* spp.), grasses, and forbs. Dry meadows are more common in Lassen, Inyo, and Modoc National Forests. California montane chaparral is a mosaic of sage scrub, chaparral, pinyon-juniper woodland, oak woodlands, and diverse forest types such as ponderosa pine, sugar pine, western white pine, and lodgepole pine. California montane chaparral occurs on all national forests in the project area (Risser and Fry 1988).

The subalpine forest biotic zone starts near 9,000 feet, where the climate is cooler and the growing season is shorter due to long cold winters. Accumulations of three to nine feet of snow are typical. The subalpine landscape contains a mosaic of subalpine forests/woodlands, meadows, rock outcrops, and scrub vegetation. Subalpine forests are open stands of conifers occurring on generally sandy soils or rocky slopes. The dominant trees are western white pine, mountain hemlock, and lodgepole pine. Stand densities are low and trees rarely exceed 80 feet in height. Meadows, rock outcrops, and shrub vegetation dominate the subalpine zone. The meadows are the same as described for the upper montane zone; they are characterized by grasses and a variety of wildflowers that flower in July and August.

The broadleaf upland forest is interspersed throughout the region, generally within the lower and upper montane biotic zones. A typical broadleaf upland habitat is composed of a dominant hardwood tree layer, with infrequent conifers and sparse shrub and herbaceous layers. In the southern Cascades and Sierra Nevada, steep, rocky south slopes of major river canyons often are covered by canyon live oak (*Quercus chrysolepis*) and scattered old growth Douglas fir. Elsewhere, higher elevation overstory associates are typically mixed conifer and California black oak; lower elevation associates are gray pine (*Pinus sabiniana*), knobcone pine (*Pinus attenuata*), tanoak (*Lithocarpus densiflorus*), Pacific madrone (*Arbutus menziesii*), and scrubby California laurel (*Umbellularia californica*). Associated understory vegetation includes Oregon grape, currant (*Ribes* spp.), wood rose (*Rosa gymnocarpa*), snowberry, manzanita (*Arctostaphylos* spp.), poison oak (*Toxicodendron diversilobum*), and a few forbs and grasses (McDonald 1988).

Sagebrush scrub is a treeless community of low shrubs stretching across much of the high desert (4,000 to 9,000 feet) and within the montane forest. It is widely distributed near the eastern base of the Cascade-Sierra Nevada crest within the counties of Modoc, Lassen, Mono, and Inyo. Characteristic species include big sagebrush (*Artemisia tridentate* ssp. *tridentate*), rubber rabbitbrush (*Chrysothamnus nauseosus*), antelope bitterbrush (*Purshia tridentata*), native perennial bunch grasses, such as ricegrass (*Achnatherum hymenoides*), needle-and-thread grass (*Hesperostipa comata*), and one-sided bluegrass (*Poa secunda*), and introduced annual grasses.

Pinyon-juniper habitat generally occurs in the southeastern portions of the Sierra Nevada at middle elevations adjoining a number of other wildlife habitats. At higher elevations, ponderosa and Jeffrey pine may be found in this habitat with dense stands of pinyon (*Pinus edulis*). At lower elevations, pinyon-juniper may interface with habitats such as Joshua tree and desert scrub. At higher elevations, habitats such as eastside pine, perennial grasses, ponderosa pine, and Jeffrey pine border on pinyon-juniper. Shrub-size plants in the subcanopy include small individuals of the overstory species, especially California juniper (*Juniperus californica*), as well as big sagebrush, blackbrush, antelope bitterbrush, and mountain mahogany (*Cercocarpus ledifolius*).

Riparian vegetation occurs in the lower montane, upper montane, and subalpine biotic zones, but is more common along low- to mid-elevation perennial and intermittent streams within the lower and upper montane biotic zones. Riparian vegetation occurs along all types of waterways, including meadows, flood plains, peatlands, marshes, springs, and lakeshores. Vegetation includes broadleaved, winter deciduous trees that form open or closed canopies, such as aspen (*Populus tremuloides*), white alder (*Alnus rhombifolia*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), willows (*Salix* spp.), western dogwood (*Cornus sericea* ssp. *occidentalis*), sedges, and rushes (*Juncus* spp.).

Vernal pools are seasonally flooded depressions found on ancient soils with an impermeable layer such as a hardpan, claypan, or volcanic basalt. The impermeable layer allows the pools to retain water much longer than the surrounding uplands; nonetheless, the pools are shallow enough to dry up each season. Vernal pools often fill and empty several times during the rainy season. Only plants and animals that are adapted to this cycle of wetting and drying can survive in vernal pools over time. In California, the greatest concentration of vernal pools is found within the Central Valley, but they do occur elsewhere, such as Lassen and Modoc National Forests in the Project Area.

Due to their unusual chemical composition, serpentine soils often support numerous rare plants that have adapted to grow there. Serpentine soils occur in the foothills of the Sierra Nevada and Cascades up to approximately 6,400 feet in elevation. Vegetation types occurring in serpentine soil habitats include grasslands, chaparral, woodlands, forest, and “serpentine barrens,” which are sparsely vegetated by annual and perennial herbaceous plant species. Forests on serpentine soils are extremely uncommon due to the low nutrient levels in the soil; however, some areas do have denser vegetation, particularly montane areas with higher rainfall such as the Cascades. In those areas, Jeffery pine and gray pine form patchy forested areas. These forests are often interrupted by open areas of serpentine barrens, and the steeper areas may support chaparral or woodlands.

5.2.4 Aquatic Communities

Wetlands (bogs, marshes, swamps, seeps, etc.), lakes, and streams support rich communities of native organisms both in the water and in adjoining riparian areas. Native fishes and their invertebrate food supply are affected by water availability and quality, habitat alteration, and introduction of exotic species. Riparian vegetation (described above) occurs next to streams, lakes, and wetlands, and is rich in species diversity. Riparian areas are important natural biofilters, protecting aquatic environments from excessive sedimentation, polluted surface runoff and erosion and can be sources for plant recolonization of surrounding areas after disturbance. Riparian areas supply shelter, food, and migration corridors for many aquatic and terrestrial animals. These areas also provide shade – an important part of stream temperature regulation

Because of the ecological value of aquatic communities, several Critical Aquatic Refuges (CARs) have been designated in the Sierra Nevada by the USFS. CARs are small subwatersheds that contain either known locations of threatened or endangered species, highly vulnerable populations of native plant or animal species, or localized populations of rare native aquatic or riparian dependent plant or animal species. The primary role of CARs is to preserve, enhance, restore, or connect habitats for rare, native, aquatic, or riparian dependent plant or animal species at the local level. In many cases, CARs support the best remaining populations of native fish, amphibian, and plant species whose distributions have been substantially reduced elsewhere in the Sierra Nevada. CARs primarily protect occupied habitat of threatened, endangered, or sensitive animal species. There are two CARs adjacent to the Jonesville trail system on Lassen National Forest (Figure 18) designated for the preservation of the Cascade frog (*Rana cascadae*) habitat, a USFS sensitive species and CDFG species of special concern.

5.2.5 Wildlife

Wildlife habitat values depend on the availability of water, food, and cover. While some wildlife species are restricted to specific vegetation communities, others range across communities and biotic zones. Many species are active in a higher zone in the summer and hibernate or migrate away from these zones in the winter. The lower montane, upper montane, and subalpine biotic zones support a large variety of mammals, birds, reptiles, amphibians, fish and insects. To give a sense of the variety, common species found in these biotic zones include yellow-bellied marmot (*Marmota flaviventris*), mule deer (*Odocoileus hemionus*), black bear (*Ursus americanus*), coyote (*Canis latrans*), mountain lion (*Puma concolor*), western gray squirrel (*Sciurus griseus*), golden-mantled ground squirrel (*Spermophilus lateralis*), chipmunks (*Neotamias spp*.), Steller's jay (*Cyanocitta stelleri*), Clark's nutcracker (*Nucifraga columbiana*), mountain chickadee (*Poecile gambeli*), white-headed woodpecker (*Picoides albolarvatus*), brown creeper (*Certhia americana*), western fence lizard (*Sceloporus occidentalis*), rubber boa (*Charina bottae*), Pacific chorus frog (*Pseudacris regilla*), big brown bat (*Eptesicus fuscus*), fringed myotis (*Myotis thysanodes*), and rainbow trout (*Oncorhynchus mykiss*). Rare species are described below under "Special-status Species."

While pre-season trail maintenance activities (removing downed limbs and debris) occur before snow falls in the winter (see Project Description, Section 2.4.3), trail grooming and subsequent OSV use in the Project Area obviously occurs only when there is snow. Wildlife that is active in the winter and may be affected by OSV Program activities includes mule deer, marmots, squirrels, chipmunks, rabbits, and resident birds such as the Steller's jay, Clark's nutcracker, and mountain chickadee, and subnivean (under the snow) species such as mice, moles, and shrews. Species excluded from this impact analysis are: 1) those that are not present during the OSV use period such as migratory animals; 2) those that hibernate and are not at risk for impacts related to OSV use (such as bears and bats); and 3) those whose habitat requirements are outside of the OSV use area. Migratory birds, including bald eagle (*Haliaetus leucocephalus*), American peregrine falcon (*Falco peregrinus*), and various waterfowl may return as early as February and overlap with the end of the OSV Program season, so they are addressed by the impact analysis.

5.2.6 Wildlife Movement Corridors

Habitat corridors facilitate wildlife migration and movement within landscapes, and are essential to the viability and persistence of many wildlife populations. Wildlife movement includes migration (i.e., usually one-way per season), inter-population movement (i.e., long-term genetic flow), and small travel pathways (i.e., daily movement corridors within an animal's territory). While small travel pathways usually facilitate movement for daily home range activities, such as foraging or escape from predators, they also provide connection between outlying populations and the main corridor, permitting an increase in gene flow among populations. These linkages among habitats can extend for miles and occur on a large scale throughout California. The Cascades and Sierra Nevada are understudied in regards to habitat connectivity patterns (Davis and Cohen 2009); however, the importance of wildlife corridors should not be under-estimated. Wildlife corridors are undoubtedly important to the long-term health of wildlife populations and the ecology of the Cascades and the Sierra Nevada.

5.2.7 Special-Status Species

Special-status species are those plants and animals that are legally protected or otherwise recognized as vulnerable to habitat loss or population decline by federal, state, or local resource conservation agencies and organizations. In this analysis, special-status species include:

- species that are state and/or federally listed threatened or endangered;
- species considered as candidates for listing as threatened or endangered;
- CDFG Species of Special Concern;
- fully protected species per California Fish and Game Code;
- USFS Sensitive Species; and
- plants considered by the California Native Plant Society (CNPS) and the CDFG to be rare, threatened, or endangered [California rare plant ranked, (CRPR); e.g. CRPR 1B).

The special-status species with potential for occurrence in the project area are listed in Appendix F and shown in Figures 16 through 36. Consistent with the CEQA Guidelines, Appendix F includes state and federally listed species as well as plants identified as rare by CNPS and CDFG and was prepared using information from the USFS (2009), the California Natural Diversity Database (CNDDB 2010), and the CNPS Rare Plant Inventory (2010). It contains information on regulatory status, habitat, and flowering period derived from the CNDDB (2010) and CNPS Rare Plant Inventory (2010). It also lists all of the special-status species that were covered by the Wildlife Habitat Protection Plans/Habitat Management Plans (USFS 2003b-k, 2007b-d) of the various national forests. Species listed in Appendix F but excluded from this analysis, are: 1) those that are not present during the OSV use period (such as migratory birds like the willow flycatcher); 2) those that hibernate (such as bears and bats) and are not at risk for impacts related to OSV use; 3) those whose habitat requirements are outside of the plowing, grooming, and OSV travel area; and, 4) those that, although potentially present in a national forest, are limited in distribution and are not expected to occur within the Project Area (such as several special-status plant species, sage grouse, and Sierra Nevada bighorn sheep). Plant species with no potential to be impacted by the Project or that are not known to occur within the Project Area as identified in Appendix F are not further addressed in this analysis; however, due to their mobility, wildlife species with a low potential for occurring within the Project Area are included and discussed in Section 5.2.7.2.

5.2.7.1 Special-Status Plant Species

The 160 special-status plant species listed in Appendix F occur in a variety of habitats present in the Sierra Nevada and Cascades, including riparian, montane chaparral, grasslands, serpentine areas, broadleaf upland forest, and closed-cone and coniferous forest (CNDDB 2010). Of these 160 plant species, 47 species are not known to occur within or adjacent to the Project Area and are therefore not further analyzed in this chapter. Considered in this analysis are the remaining113 sensitive plant species from Appendix F that could potentially be impacted by OSVs and are known to occur within or adjacent to the Project Area. Of the 113 species considered, Sequoia National Forest has studied Kern Plateau milk-vetch, Hall’s daisy, Kern River daisy, and Kern Plateau horkelia and reviewed them for impacts from OSV activity. Sequoia National Forest monitored those four species and concluded that they have not been impacted by OSV activity (Sequoia National Forest WHPP, 2003); consequently, those four species are dismissed from further analysis. A total of 109 special-status plant species are included in Table 5-2 and analyzed for impacts in general in Section 5.3.6.1.

Of the 109 listed plant species analyzed, five have been or are currently managed by national forests for OSV impacts and are described below. These plants are subject to USFS Management Actions as identified in Table 5-3. All the national forests involved with the OSV Program manage and conserve federal special-status plant species and their habitats to ensure viable populations are maintained. Monitoring of federal special-status species occurs every season. Several special-status species are considered sensitive by CNPS and CDFG but are not considered sensitive by the USFS, and therefore, they have not been actively monitored by the USFS. These California rare plant ranked species and the currently monitored federal special-status species are further described below and in Appendix F.

Barron’s Buckwheat

Barron’s buckwheat (*Eriogonum spectabile*; proposed FSS species, CRPR 1B.2), an evergreen, perennial shrub, was first discovered in 1997, and is currently only known from two occurrences in Plumas County on the Lassen National Forest. This species occurs only on minor ridge tops with light-colored sandy loam soils at a narrow elevation range of 6,600 to 6,725 feet. The occurrences are separated from each other by less than one-half mile, and contain approximately 250 plants total. Despite extensive surveys on the Lassen National Forest, no additional occurrences have been found. The occurrence with the largest number of individuals is adjacent to the Swain Mountain OSV route (Figure 19). Since its discovery, the USFS, using the CNPS’s Botanical Survey Guidelines, has consistently monitored the Swain Mountain population every year.

Management Actions by Lassen National Forest involve monitoring after snowmelt and inspecting for damage. If damage occurs, corrective action includes re-routing trails, signage, physical barriers, and/or site restoration (Table 5-3).

Table 5-2. Special-status Plant Species Within or Adjacent to Project Area Analyzed for Potential OSV Impacts

National Forest	Special-status Plant Species
Klamath	Mt. Eddy draba, Columbia yellow cress, Newberry's cinquefoil, grass alisma
Modoc	Hall's sedge, little hulsea, pyrola-leaved buckwheat, talus collomia, Boggs Lake hedge-hyssop, snow fleabane daisy
Shasta-Trinity	Mt. Eddy draba, Northwestern moonwort, pyrola-leaved buckwheat, Columbia yellow cress, Wilkins' harebell, Cascade alpine campion, Aleppo avens
Lassen	Ephemeral monkey flower, slender Orcutt grass, Barron's buckwheat, Columbia yellow cress, Newberry's cinquefoil, snow fleabane daisy, mud sedge, flat-leaved bladderwort, Lewis Rose's ragwort, rayless mountain ragwort, western goblin, long-stiped campion, Follett's monardella, water bulrush, scalloped moonwort, dwarf resin birch, Susanville beardtongue, Suksdorf milk-vetch, upswept moonwort, mingan moonwort, wooly-fruited sedge, northern spleenwort, English sundew, long-leaved starwort, broad-nerved hump moss, wooly stenotus, nodding vanilla-grass, squarestem phlox, Janish's beardtongue, little ricegrass, Egg Lake monkeyflower, obtuse starwort, three-ranked hump moss, Tracy's sanicle, Quincy lupine
Plumas	Close-throated beardtongue, Quincy lupine, Constance's rock cress, Cantelow's lewisia, caribou coffeeberry, Mildred's clarkia, Clifton's eremogone, Follett's monardella, wooly-fruited sedge, obtuse starwort, water bulrush, mingan moonwort, buttercup-leaf suksdorfia, yellow willowherb, northern coralroot, Mosquin's clarkia, Norris' beard moss, hairy marsh hedge-nettle, felt-leaved violet
Tahoe	Subalpine fireweed, close-throated beardtongue, Cantelow's lewisia, Stebbin's phacelia, Davy's's sedge, Donner Pass buckwheat, Plumas ivesia, Webber's ivesia, saw-toothed lewisia, white-stemmed pondweed, broad-nerved hump moss, slender-leaved pondweed, English sundew, three-ranked hump moss, Quincy lupine, felt-leaved violet, common moonwort, alder buckthorn, tall alpine-aster
Eldorado	Alpine dusty maidens, Kellogg's lewisia, Pleasant Valley mariposa lily
Stanislaus	Jack's wild buckwheat, subalpine fireweed, subalpine cryptantha, Masonic Mountain jewel-flower, alpine dusty maidens, cut-leaf checkerbloom, mountain bent grass
Inyo	Mono milk-vetch, field ivesia, Mono Lake lupine, Inyo phacelia, smooth saltbush, slender-leaved pondweed, Pinzl's rock cress
Sierra	Bolander's bruchia, Mono hot springs evening primrose, flat-leaved bladderwort, mud sedge, prairie wedge grass, short-leaved hulsea, Yosemite ivesia, subalpine fireweed
Sequoia	Field ivesia, short-leaved hulsea, Shirley Meadow star-tulip, copper-flowered bird's-foot trefoil, purple mountain-parsley, pygmy pussypaws, unexpected larkspur, Kaweah fawn lily, flax-like monardella, Twisslemann's buckwheat, Needles' buckwheat, Sierra bleeding heart, DeDecker's clover, Kern Plateau bird's beak, Nine Mile Canyon phacelia, Bolander's bruchia, prairie wedge grass, Kern River Daisy, Kern Plateau horkelia, Kern Plateau milk-vetch, delicate bluecup, Muir's tarplant, Greenhorn fritillary, Piute cypress, Mineral King draba, Tulare cryptantha, broad-nerved hump moss, Norris' beard moss, Madera leptisiphon, flat-leaved bladderwort, Berry's morning glory

Source: TRA Environmental Sciences, Inc. 2010

Table 5-3. USFS Management Actions for Special-Status Plant Species, OSV Program

Special-Status Species[1]	Location and Habitat	USFS Management Action
Barron's buckwheat (PFSS, CRPR 1B.2), Columbia yellow cress (FSS , CRPR 1B.2)	Barron's buckwheat occurs on open, glaciated ridges in red fir and lodgepole pine forests in the Lassen National Forest. Columbia yellow cress occurs in meadows and seeps in pinyon and juniper woodlands in the Klamath, Shasta-Trinity, and Lassen National Forests.	Klamath, Shasta-Trinity, and Lassen National Forests: Monitor Barron's buckwheat and Columbia yellow cress after snowmelt inspecting for damage. If damage occurs, corrective action includes re-routing trails, signage, physical barriers, and/or site restoration. Columbia yellow cress occurs within the Lava Beds National Monument where OSVs are not allowed; consequently, no management actions area required in the Monument.
Slender Orcutt grass (FT, SE, CRPR 1B.1)	Slender Orcutt grass occurs in vernal pools in the Lassen National Forest.	Lassen National Forest: Spring monitoring for slender Orcutt grass was discontinued after 2007. The Swain Mountain kiosk provides educational materials.
Mono milk-vetch (FSS, CRPR 1B.2) Mono Lake lupine (FSS, CRPR 1B.2)	Gravelly or sandy pumice flat openings in Jeffrey pine and lodgepole pine forest in the Inyo National Forest.	Inyo National Forest: Monitor snow depth in pumice flats where both of these plant species occur, particularly Smokey Bear Flat in the Lookout Loop use area. Permit OSV use only when there is sufficient snow cover to protect soil and vegetative resources. OSV outfitters and USFS educate users regarding snow conditions and appropriate use areas.
[1]Listing Status Key: FT – Federal Threatened FSS – USFS Sensitive Species PFSS – Proposed USFS Sensitive Species SE – State Endangered		CRPR 1B: Plants rare, threatened, or endangered in California and elsewhere. CRPR Threat Code extensions and their meanings: .1 - Seriously endangered in California (over 80% of occurrences threatened / high degree and immediacy of threat) .2 – Fairly endangered in California (20-80% occurrences threatened)

Source: USFS 2009

Columbia Yellow Cress

Columbia yellow cress (*Rorippa columbiae*; FSS, CRPR 1B.2), a perennial rhizomatous herb, is found in very diverse habitats that are inundated with water for at least part of the year. Specifically, this species can be found in moist areas ranging from clay to cobble rock, along rivers, playas, intermittent snow-fed streams, lakes, wet meadows, and drying lakebeds. In California, Columbia yellow cress is known from fewer than 15 occurrences, and is found in Modoc, Siskiyou, and Lassen Counties. Two occurrences are found on Lassen National Forest (Figure 19), both on large, flat playas (shallow lake bottoms). OSV riding is prohibited within the Lava Beds National Monument where an occurrence dates from 1936 (Figure 17). Columbia yellow cress also occurs on playas on the Klamath and Shasta-Trinity National Forests (Figure 17). These two occurrences are each about 4.5 miles from the nearest groomed trail. There are also five occurrences in Oregon within three counties, and two occurrences in Washington within two counties. Threats include livestock grazing, alteration of the hydrologic regimes, competition with introduced plant species, logging activities, road maintenance, and herbivory by wildlife and insects. The occurrence on the Lassen National Forest at Bogard is within an OSV open riding site. This occurrence was discovered in 1994 and was monitored annually by the USFS from 1995 to 2005. This monitoring was discontinued after it was determined that there were no adverse effects stemming from OSV activities (Lassen National Forest WHPP, 2007).

Slender Orcutt Grass

Slender Orcutt grass (*Orcuttia tenuis*, federal threatened, state endangered, CRPR 1B.1) is found in the northern portion of the Central Valley and the western edge of the Modoc Plateau. It is currently known from 79 occurrences, 73 of which are presumed extant (USFS 2003a). Lassen National Forest supports 18 known occurrences. Slender Orcutt grass and its critical habitat primarily occur north of Lassen National Park near State Route 44 (Figure 19). Another small population and its critical habitat occur adjacent to the Jonesville trailhead. Slender Orcutt grass occurs in valley grassland and blue oak woodland where it grows in vernal pools on remnant alluvial fans and high stream terraces and recent basalt flows (USFWS 2010a). Slender Orcutt grass has very specific vernal pool depth and sensitive hydrologic requirements. This is a low-growing annual grass that is dormant in winter.

Within Lassen NF, approximately 19,000 acres of critical habitat have been identified for slender Orcutt grass. The Swain Mountain kiosk contains educational materials, and fencing was installed around the Swain Mountain slender Orcutt grass population due to documented evidence of OHV impacts during summer activities. No OSVs have been documented affecting slender Orcutt grass, and the USFS monitoring after the OSV season was discontinued in 2007 (USFS 2007a) (Table 5-3).

Mono Milk-Vetch and Mono Lake Lupine

Both Mono milk-vetch (*Astragalus monoensis*; FSS, CRPR 1B.2) and Mono Lake lupine (*Lupinus duranii*; FSS, CRPR 1B.2) require special management because they have very restricted distributions. They are endemic to Mono County, from the Mono Basin area south to the Mammoth Lakes region in the Inyo National Forest. Mono milk-vetch occurs between 7,000 and 11,000 feet in elevation, and Mono Lake lupine occurs between 6,500 and 9,800 feet in elevation. Associated with sagebrush habitats, both are typically found on open pumice flats, and occasionally in coarse soils in openings in the understory of open lodgepole or Jeffrey pine forests. The open flats in particular are popular OSV play areas. Much of the primary habitat within the OSV use areas on Inyo National Forest has been surveyed and mapped for both of these species. OSV trails cross known populations, as shown on Figure 29. These plants are both low growing perennials that are dormant in the winter.

These two species are currently managed by the Inyo National Forest. Management Actions involve monitoring snow depth in pumice flats where both of these plant species occur, particularly Smokey Bear Flat in the Lookout Loop use area (Table 5-3). OSVs are permitted to use these trails only when there is sufficient snow cover to protect soil and vegetation. The USFS works with OSV outfitters to educate users regarding snow conditions and appropriate use areas.

Additional Special-status Plant Species

Threatened, endangered, and California rare plant ranked species that do not receive formal Management Actions by national forests, but that could be affected by the OSV Program, are included in Table 5-2. Please see Appendix F for habitat information.

Several California rare plant ranked species are also FSS plant species. Only one plant species that may be impacted by OSV activity is a FSS plant species and not a California rare plant ranked species, Kellogg's lewisia (*Lewisia kelloggii* ssp. *kelloggii*; Eldorado National Forest).

5.2.7.2 Special-Status Wildlife Species

A list of special-status animals potentially occurring within the Project Area is provided in Appendix F. Of the 37 listed species, 30 are either resident or commonly occurring in the Project Area during the winter season and could be potentially affected by trail maintenance, grooming, or OSV use under the OSV Program (Table 5-4). Only those species are addressed here and in the impact analysis. Special-status wildlife species occurring within the Project Area and the surrounding project vicinity are shown on maps for each trail site area (see Figures 16 through 34). Management Actions taken to protect these species are summarized in Table 5-5 and are described below for each species.

Table 5-4. Special-status Wildlife Active in Winter within Project Area

National Forest	Special-status Wildlife Active in Winter with Potential to Occur within the Project Area
Klamath	Northern goshawk, northern spotted owl, American marten, American peregrine falcon, golden eagle, mountain lion, Cascades frog
Modoc	Bald eagle, northern goshawk, northern spotted owl, American marten, Pacific fisher, American peregrine falcon, golden eagle, mountain lion
Shasta-Trinity	Bald eagle, northern goshawk, northern spotted owl, American marten, Pacific fisher, American peregrine falcon, McCloud River redband trout, golden eagle, mountain lion, Cascades frog
Lassen	Bald eagle, northern goshawk, great gray owl, California spotted owl, American marten, Pacific fisher, California wolverine, Sierra Nevada red fox, American peregrine falcon, spring-run Chinook salmon, Sierra Nevada snowshoe hare, American badger, golden eagle, mountain lion, foothill yellow-legged frog, Cascades frog
Plumas	Bald eagle, northern goshawk, California spotted owl, American marten, Pacific fisher, California wolverine, Sierra Nevada red fox, American peregrine falcon, American badger, golden eagle, mountain lion, Sierra Nevada yellow-legged frog, foothill yellow-legged frog
Tahoe	Bald eagle, northern goshawk, California spotted owl, American marten, American peregrine falcon, California wolverine, Sierra Nevada red fox, Lahontan cutthroat trout, Sierra Nevada snowshoe hare, American badger, Sierra Nevada mountain beaver, golden eagle, mountain lion, Sierra Nevada yellow-legged frog, foothill yellow-legged frog
Eldorado	Northern goshawk, California spotted owl, American marten, Sierra Nevada red fox, American peregrine falcon, Sierra Nevada snowshoe hare, golden eagle, mountain lion, Yosemite toad, Sierra Nevada yellow-legged frog, Mount Lyell salamander
Stanislaus	Bald eagle, northern goshawk, great gray owl, California spotted owl, American marten, California wolverine, Sierra Nevada red fox, American peregrine falcon, Lahontan cutthroat trout, Sierra Nevada snowshoe hare, golden eagle, mountain lion, Yosemite toad, Sierra Nevada yellow-legged frog, Mount Lyell salamander
Sierra	Bald eagle, northern goshawk, great gray owl, California spotted owl, American marten, Pacific fisher, American peregrine falcon, Lahontan cutthroat trout, American badger, golden eagle, mountain lion, Yosemite toad, Sierra Nevada yellow-legged frog, Mount Lyell salamander

Table 5-4. Special-status Wildlife Active in Winter within Project Area

National Forest	Special-status Wildlife Active in Winter with Potential to Occur within the Project Area
Inyo	Bald eagle, northern goshawk, American marten, Sierra Nevada red fox, American peregrine falcon, California golden trout, western white-tailed jackrabbit, Mt. Lyell shrew, Sierra Nevada mountain beaver, golden eagle, mountain lion, Yosemite toad, Sierra Nevada yellow-legged frog, Mount Lyell salamander
Sequoia	Bald eagle, northern goshawk, great gray owl, California spotted owl, California condor, American marten, Pacific fisher, California wolverine, American peregrine falcon, Little Kern golden trout, California golden trout, American badger, golden eagle, mountain lion, Sierra Nevada yellow-legged frog, Sierra Madre yellow-legged frog, Mount Lyell salamander
Note: In general, fish and amphibians would not be considered directly impacted by the Project (fish are underwater and amphibians hibernate during winter); however, they are considered for impacts in this analysis due to potential Project impacts to water quality. Please see Section 5.3.6.2.	

Source: TRA Environmental Sciences, Inc. 2010

Table 5-5. USFS Management Actions for Special-Status Wildlife Species, OSV Program

Special-Status Species[1]	Location and Habitat	USFS Management Action
northern goshawk (FSS, CSSC)	Mature coniferous forests and riparian aspen groves serve as both nesting and foraging habitat. Nests in a wide variety of forest types including deciduous, coniferous, and mixed forests across all national forests.	<u>All OSV Program national forests</u>: Monitoring of northern goshawk Protected Activity Centers (PACs). Limited operating period (LOP) on groomed trails within 1/4 mile of nest sites after February 15 where there is documented evidence of disturbance from existing recreation activities.
northern spotted owl (FT, CSSC)	Inhabits old growth forests in the northern part of its range (Canada to southern Oregon) and landscapes with a mix of old and younger forest types in the southern part of its range (Klamath region and California).	<u>Klamath, Modoc, and Shasta-Trinity National Forests</u>: Monitoring of northern spotted owl PACs. LOP on groomed trails within 1/4 mile of nest sites after February 15 where there is documented evidence of disturbance from existing recreation activities.
California spotted owl (FSS, CSSC)	Resides in dense, old growth, multi-layered mixed conifer, redwood, and Douglas-fir habitats, from sea level up to approximately 7,600 feet.	<u>Eldorado, Lassen, Plumas, Sequoia, Sierra, Stanislaus, and Tahoe National Forests</u>: Forest monitoring of California spotted owl PACs. LOP on groomed trails within 1/4 mile of nest sites after March 1 where there is documented evidence of disturbance from existing recreation activities.

Table 5-5. USFS Management Actions for Special-Status Wildlife Species, OSV Program

Special-Status Species[1]	**Location and Habitat**	**USFS Management Action**
bald eagle (SE, SFP)	Preferentially roosts in conifers or other sheltered sites in winter in some areas; typically selects the larger, more accessible trees. Wintering areas are commonly associated with open water, though in some areas eagles use habitats with little or no open water if other food resources are readily available.	Inyo, Modoc, and Plumas National Forests: Annual checks in late winter on nesting/roosting territories within 1/4 mile of groomed trails for nest success, roost disturbance, and OSV off trail use.
American peregrine falcon (FSS, SE [proposed for delisting], SFP)	Includes most of California during migrations and winter. The breeding range includes the Cascade and Sierra Nevada. Nests on ledges in rock outcrops and needs open or edge areas for foraging.	All OSV Program national forests: Monitor and protect existing and historical nests from disturbance using signage and trail closures. Stanislaus National Forest also prohibits new OSV activity w/in 200 feet of lake shorelines that are used by peregrine falcons.
great gray owl (FSS, SE)	Generally occurs in mature conifer stands associated with high-mountain meadows. Winter range is the same except at a lower elevation with thinner snow cover.	Sequoia, Sierra, and Stanislaus National Forests: Forest monitoring of great gray owl PACs. LOP on groomed trails within 1/4 mile of nest sites after February 15 where there is documented evidence of disturbance from existing recreation activities.

Table 5-5. USFS Management Actions for Special-Status Wildlife Species, OSV Program

Special-Status Species[1]	Location and Habitat	USFS Management Action
American marten (CDFG code Section 4700, FSS)	Mature and old-growth coniferous forests with large diameter trees and snags, large down logs, and moderate-to-high canopy closure interspersed with riparian areas and meadows.	Inyo, Shasta-Trinity, Stanislaus National Forests: Implement LOP or enforce trail closures from May 1 – July 31 within ¼ mile of identified den site. Install restrictive signs in areas prone to illegal off-trail use. Sierra and Tahoe National Forests: Enforce LOP from March 1 through June 30, within ¼ mile of den site if analysis determines that OSV activities are causing noise disturbance to martens. Klamath National Forest: Provide informational and educational materials to prevent harassment of wildlife. Patrol trails with USFS or snowmobile club personnel. Plumas National Forest: Implement trail closures or rerouting of selected portions of OSV trails within ¼ mile of identified den site. Install proper signage and increase patrolling to educate and enforce these measures. Sequoia National Forest: If wildlife appears to be affected, implement trail closures or alternate routes, or implement other mitigation.
Pacific fisher (FC, FSS, CSSC, SC)	Prefers mature and old growth forest with structural diversity, downed wood, and high canopy closure. When inactive, occupies a den in a tree hollow, under a log, or in the ground or a rocky crevice.	Sequoia and Sierra National Forests: Forest monitoring for presence of Pacific fisher. LOP on groomed trails within 1/4 mile of known den sites after March 1.
California wolverine (FSS, ST, SFP)	Prefers areas with low human disturbance. Habitat includes alpine and arctic tundra and boreal and mountain forests. Typically found in areas with snow on the ground in winter. When inactive, occupies dens in caves, rock crevices, fallen trees, thickets, or similar sites, generally in denser forest stages.	All OSV Program national forests: Part of annual winter inventory monitoring for forest carnivores. Sierra National Forest: LOP on groomed trails March 1 – June 30. Plumas National Forest: Trail closure and rerouting OSV trails if disturbance is identified.

Table 5-5. USFS Management Actions for Special-Status Wildlife Species, OSV Program

Special-Status Species[1]	Location and Habitat	USFS Management Action
Sierra Nevada red fox (ST, FSS)	Limited to the conifer forests and rugged subalpine areas near treeline between 5,000 feet and 12,000 feet	Sierra National Forest: Enforce LOP from March 1 through June 30 if annual monitoring determines that OSV activities are causing noise disturbance to the fox. Plumas National Forest: Implement trail closures and rerouting of selected portions of OSV trails if disturbance is identified through the monitoring process.
Yosemite toad (*Anaxyrus canorus*; FC, FSS, CSSC)	After breeding in shallow pools and the margins of lakes or streams, males and females move from the breeding site to meadows where they feed for two to three months before the snows return. During winter, Yosemite toads shelter in rodent burrows, willow thickets, forest edges adjacent to meadows, and in clumps of vegetation near water.	Sierra National Forest: Implement temporary closures (closed or LOP from snowmelt to July 31st) for aquatic wildlife protection, implemented during the critical breeding season.

[1]Listing Status Key:

FE – Federal Endangered	SE – State Endangered
FT – Federal Threatened	ST – State Threatened
FC – Federal Candidate	SC – State Candidate
FSS – USFS Sensitive Species	CSSC – Calif. Species of Special Concern
	SFP – State Fully Protected

Source: USFS 2009

Bald Eagle

The bald eagle, once severely endangered, was removed from the federal endangered species list in August 2007, but remains a California threatened species as well as a California fully protected species. The bald eagle is a large bird of prey that eats a variety of mammalian, avian, and reptilian prey, but generally prefers fish to other food types. It often scavenges prey items when available, pirates food from other species when it can, and captures its own prey only as a last resort. The bald eagle requires large bodies of water, or free flowing rivers with abundant fish, and adjacent snags or other perches. Adults in California usually do not migrate but remain year-round near their nest site; however, they may be less closely associated with the nest in winter than during the breeding season (Buehler 2000).

Wintering bald eagles range across most of the lower 48 states, coastally in Alaska and Canada, and locally in Mexico. In California, bald eagles are found throughout the Sierra Nevada and Cascades. Breeding generally occurs February to July (Polite and Pratt 1999) but breeding can be initiated as early as January 1 via courtship, pair bonding, and territory establishment. The breeding season normally ends by August 31 when the fledglings have begun to disperse from the immediate nest site. Bald eagles are susceptible to disturbance by human activity during the breeding season, especially during egg laying and incubation, and such disturbances can lead to nest desertion or disruption of breeding attempts (USFWS1986). Two habitat characteristics appear to play a significant role in habitat selection during the winter: diurnal feeding perches and communal night roost areas. Most communal winter roosts offer considerably more protection from the weather than diurnal habitat (USFWS1986). Human activity near wintering eagles can adversely affect eagle distribution and behavior (USFS 2003f). Inyo, Modoc, and Plumas National Forests perform annual checks in late winter on nesting/roosting territories within 1/4 mile of groomed trails for nest success, roost disturbance, and OSV off-trail use. The bald eagle occurs on all 11 national forests but not necessarily along the groomed trail system or within the broader Project Area (Figures 16 through 34).

Golden Eagle

The golden eagle (*Aquila chrysaetos*) is a California fully protected species and is one of North America's largest predatory birds. More common in southern California than in northern California, this species ranges from sea level up to 11,500 feet. Its habitat typically consists of rolling foothills, montane areas, sage-juniper flats, and desert; it avoids heavily forested areas. The golden eagle eats mostly rabbits and rodents, but also other small mammals, birds, reptiles, and carrion. The diet is most varied in the nonbreeding season. Open terrain is required for hunting such as grasslands, deserts, savannahs, and early successional stages of forest and shrub habitats. Breeding begins in late January with eggs laid from early February to late May. Only one egg is laid at a time. Golden eagles nest on cliffs of all heights and in large trees in open areas. Alternative nest sites are often maintained and old nests are reused. The nest is usually a large platform nest, often 10 feet across and 3 feet high made of sticks, twigs, and greenery. Rugged, open habitats with canyons and escarpments are used most frequently for nesting. Nest construction begins in fall and continues through the winter (Kochert et al. 2002). They winter in areas between 1,500 feet and 8,200 feet.

Humans cause greater than 70% of recorded golden eagle deaths, directly or indirectly (Franson et al. 1995). Accidental trauma (collisions with vehicles, power lines, or other structures) is the leading cause of death (27%), followed by electrocution (25%), gunshot (15%), and poisoning (6%; Franson et al. 1995). Recreation and other human activity near nests can cause breeding failures, but most evidence is anecdotal or tied to multiple variables (Kochert et al. 2002). Golden eagle sightings are not commonly reported and not monitored by USFS. The CNDDB only has 11 occurrences of the golden eagle, and none are within the Project Area, but they are presumed present.

Northern Goshawk

The northern goshawk (*Accipiter gentilis*) is a FSS species as well as a California species of special concern. A large forest raptor, the goshawk is a powerful hunter capable of killing a variety of prey including tree squirrels, hares, grouse, and other birds such as corvids and American robins (Squires and Reynolds 1997). The goshawk prefers dense, mature conifer and deciduous forest, interspersed with meadows, other openings, and requiring riparian areas in close proximity. Nesting habitat usually includes moderate north-facing slopes near water in mature forests with an open understory. As top-trophic level carnivores with large spatial requirements, low breeding density, and association with late-seral forest (old growth), goshawks are of increasing conservation concern due to forest management practices that reduce or fragment habitat.

The northern goshawk is a year-round resident throughout most of California (Figures 16-34). The primary threat to northern goshawks concerns the effects of vegetation management on the distribution, abundance, and quality of habitat (Keane 2000). The nesting home range of goshawks contains three components: the nest area, the post-fledging family area, and the foraging area, each with its individual characteristics and management requirements. Nesting pairs usually return to nesting territories by late March or early April and eggs are usually laid late April to early May (Squires and Reynolds 1997). The USFS has designated PACs in an effort to protect breeding goshawks from timber cutting and other forest management activities that can disrupt breeding. Northern goshawk PACs are designated based upon the latest documented nest site and the location(s) of alternate nests, or the location of territorial adult birds or recently fledged juvenile goshawks during the fledgling dependency period if the actual nest site is not located. PACs are delineated to include the known and suspected nest stands, and encompass the best available 200 acres of forested habitat in the largest contiguous patches that are possible based on aerial photography. Breeding requirements have been well-studied (Graham et al. 1994). The winter requirements are poorly understood, with most research taking place in northern Europe, but the few studies available show goshawk abundance in winter is primarily dependent on food source availability, not habitat preferences (Squires and Reynolds 1997).

New biological studies are being conducted by national forests in order to address potential impacts of OHV/OSV activity on northern goshawk. The Regional Northern Goshawk Focused Study has completed 4 years of data collection on Plumas National Forest. Data have been collected on hawk behavior and reproductive success with paired OHV use and hiker experiments. Radio-tagged dispersing juveniles and foraging adults were tracked. Final data analysis for the goshawk study is expected to be completed in 2010. Results of this study will be incorporated into the OHV/OSV Management Actions of the affected national forests.

Great Gray Owl

The primarily nocturnal great gray owl (*Strix nebulosa*) is listed as endangered in California and is a USFS sensitive species. The great gray owl is North America’s largest owl, in terms of length, and is primarily a rare boreal forest inhabitant. Suitable habitat exists in parts of the Sierra Nevada, most notably around Yosemite National Park (CNDDB 2010; Bull and Duncan 1993). The southern Sierra Nevada is the southern-most limit of the species’ range in North America. The great gray owl is found at higher elevations and shows a strong affinity for dense forests affiliated with wet meadows (Bull and Duncan 1993) (Figures 24, 26, 28, 30, and 34). In the Sierra Nevada, breeding habitat may be limited to elevations of roughly 3,000 to 8,000 feet, but generally occurs between 4,500 and 7,500 feet.

In 1986, the California great gray owl population was estimated at 60 to 70 individuals (Winter 1986 as cited in CDFG 2008). Currently, it is generally accepted that the owl is a rare inhabitant of the Sierra Nevada whose population does not likely exceed 200 to 300 individuals (CDFG 2008). It is suspected that there are individuals in the northern Sierra Nevada and the Cascades within California, but that has not been documented (CDFG 2008). Loss of mature forest habitat for nesting and the degradation of montane meadows remain the major sources of habitat loss.

California Spotted Owl

The primarily nocturnal California spotted owl (*Strix occidentalis occidentalis*) is a FSS species. The California spotted owl is one of three recognized subspecies of spotted owls. It is intermediate in color between the darker northern spotted owl (*S.o. caurina*) and lighter Mexican spotted owl (*S. o. lucida*). It is found in the southern Cascades and northern Sierra Nevada from Shasta County south through the remainder of the western Sierra Nevada and Tehachapi Mountains to Kern County and is sometimes found east of the Sierra Nevada crest (Figures 18-26 and 30-34). Largely associated with old growth/mature forests with high canopy cover and high tree density, these owls are susceptible to timber harvest and other forest management practices. Similar to the northern spotted owl, this owl is monogamous and territorial; divorce occasionally occurs (this has never been observed in northern spotted owl; Gutiérrez et al. 1995). The USFS has designated PACs in an effort to protect breeding California spotted owls from timber cutting and other forest management activities. California spotted owl PACs are delineated surrounding each territorial owl activity center detected on national forest System lands since 1986. Spotted owl PACs are delineated, using aerial photography, to include the known and suspected nest stands, and encompass the best available 300-acres of habitat in as compact a unit as possible. Home range core areas (HRCAs) surround spotted owl PACs. Size of HRCAs vary from forest to forest and is defined in the individual forest plans. For example, on the Stanislaus National Forest HRCAs are 1000 acres of the best available contiguous habitat within 1.5 miles of a PAC (Carly Gibson, pers. comm., 2009).

In general, California spotted owls are nonmigratory, remaining within the same home ranges year round. However, in the Sierra Nevada, some migration downslope to winter ranges occurs (USFWS 2005). Spotted owl habitat is adversely affected by wildfire, fuels-reduction activities, timber harvest, tree mortality and development (USFWS 2005). They also face competition from non-native barred owls.

Northern Spotted Owl

The primarily nocturnal northern spotted owl (*Strix occidentalis caurina*) is a federal listed threatened species and a California species of special concern (Figure 16). The northern spotted owl range extends from British Columbia south to the southern Cascades and along the California coast south to Marin County. This owl is territorial and monogamous. Courtship behavior usually begins in February or March, and females typically lay eggs in late March or April. The timing of nesting and fledging varies with latitude and elevation (Gutiérrez et al. 1995). Northern spotted owls are nonmigratory, remaining within the home range year round. After reaching maturity (one year), juveniles disperse usually less than 60 miles and typically less than 15.5 miles.

Numerous management plans and reviews of the owl’s ecological status have been developed to enhance conservation of the species (Gutiérrez et al. 1995). USFWS uses a circle of 0.7-mile radius (984 acres) from the activity center to delineate the most heavily used area during the nesting season. Northern spotted owls use smaller home ranges during the breeding season and often increase their home range size during fall and winter (USFWS 2008a). A final recovery plan was issued in 2008 by the USFWS. Even with intensive maintenance and restoration of suitable habitat in recent years, many populations of spotted owls continue to decline (USFWS 2008a). The recovery plan identified the invasive barred owl as presenting a significant threat to the northern spotted owl.

American Peregrine Falcon

The American peregrine falcon is a California endangered species (proposed for delisting) and a California fully protected species. It is still protected under the MBTA. Like bald eagles, the peregrine falcon was added to the federal endangered species list due to the effects of dichloro-diphenyl-trichloroethane (DDT). After decades of work to aid in its recovery, including extensive re-introduction efforts, the peregrine falcon has recovered to the extent that it was removed from the federal endangered species list in 1999.

One of the most widespread species, the peregrine falcon occurs on every continent except Antarctica. The peregrine falcon nests on high cliffs and on bare ledges. A nearby water source is required during breeding season. Peregrines forage most commonly in open habitats such as marshes, open grasslands, coastal strands, and bodies of water where prey cannot easily escape attack. The peregrine falcon primarily eats songbirds that were captured in flight and occasionally can be found eating rodents. Breeding times vary depending on latitude. In southern California, the first egg is laid mid- to late-February, while in northern California the first egg is laid usually in May but replacement clutches occur as late as September (White et al. 2002). The species is known to occur on all Project forests and cannot be mapped at one particular location.

California Condor

The California condor (*Gymnogyps californianus*) is a California and federal endangered species, as well as a California fully protected species. The condor is one of the most endangered birds in the world. By 1987, the only California condors in existence were living at the San Diego Wild Animal Park and the Los Angeles Zoo. Since then, considerable captive breeding has taken place and reintroduction to the wild has been attempted. A single egg clutch and six years to reach sexual maturity in the wild make the California condor a difficult species to restore to a viable population (Meretsky et al. 2000). The California condor has a high rate of mortality historically caused by poisoning and shooting. This species is strictly a scavenger, subsisting on carrion exclusively.

Since releasing began in 1992, the California condor has been returned to several locations in southern California and northern Arizona. Historically, the California condor was known to forage from beaches to high mountain meadows. While most nesting occurs on mountainous cliffs, some have nested in large cavities in giant sequoia (*Sequoiadendron giganteum*; Snyder and Schmidt 2002). This species' range extends from the mountain ranges surrounding the southern San Joaquin Valley, including the Coast Ranges from Santa Clara County south to Los Angeles County, the Transverse Ranges, the Tehachapi Mountains and southern Sierra Nevada. The California condor requires open habitat, such as grasslands and foothill chaparral, for extended soaring and easily accessible food. Traditional roosts are ledges and cliffs, but also include old-growth Douglas fir and ponderosa pine. California condor is not a migratory species; however, subadults and non-breeding adults often move to the southern Sierra Nevada from March to May and return south for the summer. Breeding adults remain near nesting areas year-round (Polite 1988-1990). With regard to the OSV Program, only Sequoia National Forest contains suitable and/or critical habitat for the condor (Figure 32). Recent monitoring results show that breeding is unlikely, but the species does use the Sequoia National Forest for foraging and roosting.

American Marten

The American marten (*Martes americana*) is a state protected fur-bearing animal (CDFG Code Section 4700) and a FSS species (Figures 16-20). The marten is a carnivorous mammal found at high elevations in the southern Cascades and Sierra Nevada and, along with the fisher, is considered one of the most habitat-specialized mammals in North America (Zielinski et al. 2005). Martens prefer late seral and old growth forest habitat with large diameter trees and snags, large down logs, and moderate-to-high canopy closure interspersed with riparian areas and meadows. Historical populations were extirpated by trapping and habitat alterations. Male martens are larger than females weighing up to 3.3 lbs for the male and up to 2.2 lbs for the female (Powell et al. 2003). Small mammals, such as mice and voles, birds, insects, and fruit make up the main diet of a marten, and they forage on the ground, in trees, snags, logs, and rocky areas. Active year-round, habitat with limited human use is important (Zielinski et al. 2007). Mostly nocturnal, they are non-migratory; however, it is believed some individuals move to lower elevations in the winter. Martens mate in the summer months, usually June to August. Implantation is delayed until February when the fertilized egg implants itself and the litter is born in March to early April (Powell et al. 2003).

In 2005, Zielinski et al. showed that populations between the southern Cascades and Sierra Nevada have become discontinuous, and there are large gaps between historical and contemporary occurrences. Recent marten detections were clustered near Lassen Volcanic National Park and adjacent protected wilderness areas, as well as just east of Mt. Shasta. These areas have intact late seral and old growth forests. The marten does appear to have a continuous distribution across high-elevation forests from Placer County south to Tulare County. The marten is particularly vulnerable to habitat disturbance with the main threat being habitat alteration.

Monitoring for marten occurs on all forests in the Sierra Nevada at a higher intensity than for fishers (USFS 2004a), with sampling concentrated on the Sierra and Sequoia National Forests. From 2002 to 2007, 1099 primary sample units were sampled throughout the Sierra Nevada. Marten has been regularly detected on Sierra National Forest and parts of Sequoia National Forest, though most sampling occurs at elevations lower than where martens are presumably most abundant. Martens are more commonly detected on Sierra National Forest than on Sequoia National Forest, and have not been detected on the west slope of Sequoia National Forest south of Tulare County. No marten detections have been recorded on the Kern Plateau on Sequoia National Forest during annual monitoring (USFS 2007a).

Pacific Fisher

The Pacific fisher (*Martes pennanti*) is a California species of special concern, a FSS species, and is a candidate for federal listing by the USFWS (Figures 16-32). Like the marten, a close relative, the fisher is a carnivorous mammal occupying late seral and old growth forests, but in California, fishers are more closely associated with riparian areas and lower elevations than martens (Powell et al. 2003). Historical populations were extirpated by trapping and habitat alterations. The fisher is the largest member of the genus *Martes* with males generally weighing 7.5 to 12 lbs and females generally weighing 4.5 to 5.5 lbs (Powell et al. 2003). Fishers are one of the few predators of porcupines, including them in their diet of small mammals, fruit, truffles, and plants. Fishers prefer closed-canopy habitats and generally avoid openings. Female fishers usually give birth in late February to early May, with most litters born in March or early April.

Breeding takes place 7 to 10 days later. Like martens, implantation is delayed until the following winter (Powell et al. 2003).

The Pacific fisher occurs at relatively low elevations (elevations range from 2,000 feet to 7,000 feet), placing it in closer proximity to human activities than the marten. In winter, fishers typically do not occur where snow is deeper than 5 or 6 inches; it is believed that snow depth affects the ability to travel and lowers reproductive success (Krohn et al. 1997). Few historical records exist in the northern Sierra Nevada and southern Cascades; this is also the same area that fisher has not been detected in more recent surveys (Zielinski et al. 2005). It is possible that trapping had extirpated the species from this area by the time the first assessments were done. From 2002 to 2007, 1099 primary sample units were sampled by the USFS throughout the Sierra Nevada. Fishers were detected at 111 sample units (45 on Sierra National Forest, 64 on Sequoia National Forest, one in Yosemite National Park, and one in Sequoia–Kings Canyon National Park). The Pacific fisher's threats are habitat loss and fragmentation, small population sizes and isolation, and human-caused mortality from incidental trapping and vehicle collisions.

California Wolverine

The California wolverine (*Gulo gulo*) is a California threatened species, a California fully protected species, and a FSS species (Figures 16, 18, and 22-34. In California, the wolverine once occurred throughout the Sierra Nevada, Cascades, Klamath, and northern Coast ranges in forests in alpine, boreal forest, and mixed forest vegetation types (Schempf and White 1977). There are few studies about wolverine habitat use in the coterminus U.S.; the results of a five-year study (Copeland 2007) indicate that the wolverine inhabits tundra, remote mountains, and boreal forests at elevations between 7,800 and 8,500 feet. In general, wolverines live at or above timberline, moving to lower elevations in winter likely due to prey availability. Primarily nocturnal, wolverines are difficult to observe, even when they are abundant (Banci 1994). An empirical wolverine habitat model developed for the Rocky Mountains found that wolverine occurrence was strongly associated with low human population density and low road density (Carroll et al. 2001). Females will give birth in natal dens as early as January or as late as April (Banci 1994). Snow tunnels or snow caves are characteristic natal and maternal dens for wolverine in many areas (Banci 1994) and, in general, females choose remote alpine talus slopes with snow cover until late spring (Carroll et al. 2001).

Wolverines are highly mobile and have extremely large home ranges, estimated at 150 square miles for females and 355 square miles for males, including long distance excursions (Banci 1994). By the early 1900s, the wolverine's distribution was limited to the southern Sierra Nevada (Zielinski et al. 2005); however, it has not been observed there for decades. The last known population was documented in 1937 and occurred at very low densities in alpine and sub-alpine habitats in the southern Sierra Nevada (8,200 to 13,000 feet; Grinnell et al. 1937 in Moriarty et al. 2009). In February of 2008, a wolverine was photographed by a remote-controlled camera on the Tahoe National Forest, much farther north than an individual from the California population would be expected. A genetic analysis showed that the individual was a male individual more closely related to populations in the western Rocky Mountain region (Moriarty et al. 2009). This sighting is a unique occurrence and suggests that dispersal to long-vacant portions of a species range is possible. Regardless of this individual's origin, wolverines and this individual are protected by California. Several studies have concluded that the wolverine is very sensitive to humans because, in the U.S. it is now only found in remote and isolated areas (Carroll et al. 2001, Rowland et al. 2003, May et al. 2006). It is suspected that there are only 500 individuals in the contiguous U.S., with the effective population size (the total number of individuals successfully breeding) at 39 (USFWS 2008b).

Sierra Nevada Red Fox

The Sierra Nevada red fox (*Vulpes vulpes necator*) is a California threatened species and a FSS species (Figures 16-22 and 28, 30, and 34). North American mountain red fox ecology is poorly known (Perrine et al. 2010). Only three ecological studies have been conducted. The lack of targeted scientific research on this species is a major factor complicating their effective management (Perrine et al. 2010). This subspecies of red fox is distinguished from members of the introduced lowland population of red foxes by its slightly smaller size and darker colored fur. Primarily nocturnal, the range of the Sierra Nevada red fox is limited to the conifer forests and rugged subalpine areas near treeline between 5,000 feet and 12,000 feet (Perrine et al. 2007). Open areas are used for hunting, forested habitats for cover and reproduction. Edges are utilized extensively for tracking and stalking prey. The red fox hunts small and medium-sized mammals, ground squirrels, gophers, mice, marmots, woodrats, pikas, and rabbits. In general, red foxes breed from December to April with most matings occurring in January and early February. Perrine (2005) showed that Sierra Nevada red foxes have distinct seasonal movements between their summer and winter ranges. Summer home ranges in Perrine's 2005 study ranged from 647 to 17,250 acres with a mean of 5740 acres. In winter, the foxes moved to significantly lower elevations and centered their home ranges on parking lots and campgrounds in Lassen Volcanic National Park and just south of the Park near Morgan Summit trailhead. In 2002, one red fox was photographed by a camera trap at the Swain Mountain snowmobile park (Perrine 2005). Winter home ranges are generally larger than summer's due to diminished food supply (Perrine 2005).

Historically, the Sierra Nevada subspecies of the red fox occupied habitat in the Sierra Nevada from Tulare County north to Sierra County as well as areas around Mt. Shasta and Lassen Peak. The current range is unknown and recent research in the vicinity of Lassen Peak estimated that only 10-15 individuals were likely present in the area (Perrine 2005; Perrine et al. 2007). Unconfirmed sightings exist on other national forests in the Sierra Nevada, but those sightings are all more than 20 years old and have not been verified. The USFS Redwood Science Laboratory conducted a seven-year (1996-2002) systematic carnivore survey of the entire Sierra Nevada and southern Cascade range, including the Lassen Peak region and no red foxes were detected (Zielinski et al. 2005). Its current distribution, population size, and demographic trend are unknown (Perrine 2005). The Sierra Nevada red fox likely occurs at low population densities even within areas of high relative abundance and an abundance of sightings is not necessarily indicative of a large local population (Perrine et al. 2008). Most of the hundreds of red fox sighting reported in Lassen Volcanic National Park were due to three human-acclimated individuals (Perrine and Arnold 2001 in Perrine et al. 2010).

Until recently, the species had only been confirmed on Lassen National Forest where begging behaviors at trailheads were observed posing potential conflicts with humans (Perrine 2005; Perrine et al. 2007). However, on September 2, 2010, the Humboldt-Toiyabe National Forest announced that a Sierra Nevada red fox sighting had been confirmed during annual monitoring activities on August 11 for Pacific fisher and American marten in the Sonora Pass area (USFS 2010); subsequently, there have been at least 2 additional confirmed detections (Diana Craig, pers. comm., 2010). The last known sighting in this area dated from the 1920s. The genetic signature of this sighting indicates that the animal is from a Sonora Pass population distinct from the Lassen National Forest population (USFS 2010). The sightings took place in an area where the Humboldt-Toiyabe and Stanislaus National Forests and Yosemite National Park come together. Highway 108, running through the Sonora Pass, is closed during the winter, and the Snow Program does not operate on the Humboldt-Toiyabe. The OSV Program grooming along Highway 108 ends at Kennedy Meadows approximately 8 miles west of the Sonora Pass.

Mountain Lion

The mountain lion, also called cougar, panther, and puma, is a “specially protected” species under Sections 4800 et seq. of the Fish and Game Code, making mountain lion hunting illegal in California. It is illegal to take, injure, possess, transport, import, or sell any mountain lion or part of a mountain lion. Mountain lions may be killed only 1) if a depredation permit is issued to take a specific lion killing livestock or pets; 2) to preserve public safety; or 3) to protect listed bighorn sheep. Mountain lion diet generally consists of large prey, such as deer, bighorn sheep and elk. However, they can also survive on small animals. They usually hunt alone and at night. They often cover the carcass with dirt, leaves or snow and may come back to feed on it over the course of a few days. Mountain lions live in many different types of habitat in California, from deserts to the humid coast range forest, and from sea level to 10,000 ft in elevation. They prefer areas with dense undergrowth and cover and they generally will be most abundant in areas with plentiful deer. An adult male's home range often spans over 100 square miles. Females generally use smaller areas, about twenty to sixty square miles. Along the Sierra Nevada’s western slope, where competition for habitat is intense, as many as ten adult lions occupy the same 100 square mile area. In California, mountain lion populations have grown in recent decades. Field studies in the 1970s indicate a population of more than 2,000 mountain lions, whereas a 2007 report estimated population ranges of 4,000 to 6,000 individuals (CDFG 2007). Mountain lions are known to occur across all forests and cannot be mapped at one particular location.

Sierra Nevada Snowshoe Hare

The Sierra Nevada snowshoe hare (*Lupus americanus tahoensis*) is a California species of special concern (Figures 22 and 26). The snowshoe hare is found in young, upper montane forests favoring habitats with a dense shrub layer. This species occurs within riparian habitats with thickets of alders and willows, and in stands of young conifers interspersed with chaparral. Mixed conifer, subalpine conifer, red fir, Jeffrey pine, lodgepole pine, and aspen are likely habitats, primarily along edges, and especially near meadows. Preferred cover includes brush adjacent to both meadows and riparian deciduous vegetation at altitudes above 4,000 feet in the north of their range and 5,000 feet in the south. Upper elevation limits are unknown, but they generally occur below 8,000 feet. The snowshoe hare is most active at dawn and dusk (crepuscular) and active all year. This species molts to a white coat in winter and a brown coat in summer. The range of this species in California extends from the southern Cascades to Tuolumne County. The only national forest in the Project Area not having the snowshoe hare is Sequoia National Forest (USFS 2004b). Snowshoe hares eat a variety of plant materials. The snowshoe hare’s diet varies with the season. Succulent green vegetation is consumed when available from spring to fall; after the first frost buds, twigs, evergreen needles, and bark form the bulk of snowshoe hare diets until spring greenup. There is no evidence of this species’ decline although it is vulnerable to habitat alterations due to logging and use of meadows for agriculture (USFS 2004b). This species remains a harvest species in California.

Western White-tailed Jackrabbit

The western white-tailed jackrabbit (*Lepus townsendii townsendii*) is a California species of special concern (Figures 20 and 28). This species is limited to higher elevations in the eastern Sierra Nevada and southern Cascades with its range in California extending from the Oregon border south to Tulare and Inyo counties. Preferred habitats for this species include sagebrush, subalpine conifer, juniper, alpine dwarf-scrub, and perennial grassland. Low sagebrush, wet meadow, and early successional stages of various coniferous communities are also used. Within these communities, the western white-tailed jackrabbit prefers open areas with scattered shrubs and exposed flat topped hills with stands of trees, brush, and herbaceous understory. The white-tailed jackrabbit is active at dawn and dusk and rests in shallow depressions at the base of a shrub or in a cavity in the snow. This jackrabbit is often found in open areas and flat-topped hills with open stands of trees. Winters are mostly spent in areas of sagebrush or in thickets of young trees.

Mount Lyell Shrew

The Mount Lyell shrew (*Sorex lyelli*) is a California species of special concern (Figure 28). Not much was known about the Mount Lyell shrew until recently. Once known from only a few occurrences near Mount Lyell, the highest peak in Yosemite National Park, its known range has been extended to include a more widespread distribution in high (above 6,500 feet) montane and sagebrush communities of the central and eastern Sierra Nevada slopes. This species is typically found in subalpine herbaceous vegetation along fast-moving streams associated with riparian shrubs, and less frequently in subalpine sagebrush thickets. The most recent occurrence, at 11,900 feet in elevation, is from an alpine lakeshore above treeline, with vegetation limited to grasses, sedges, and forbs (Epanchin and Engilis 2009).

American Badger

An uncommon resident, the American badger (*Taxidea taxus*) is a California species of special concern (Figures 16-22). Adults of this non-migratory species are primarily nocturnal, whereas juveniles are mostly active during the day. Badgers are active year round; however, in the winter, they go through states of torpor for variable periods (up to 29 hours; Long 1973). Badgers are found in a variety of open, arid habitats and are mostly associated with grasslands, mountain meadows, and desert scrub. Friable soils, a sufficient prey base of rodents, and uncultivated ground are required. The American badger’s distribution extends throughout California and the elevational range extends from below sea level (Death Valley) to over 12,000 feet.

Sierra Nevada Mountain Beaver

The Sierra Nevada mountain beaver (*Aplodontia rufa californica*) is a California species of special concern (Figures 22 and 28). The only living members of the Aplodontidae family, mountain beavers are rabbit-sized, stocky rodents. Not related to true beavers, the mountain beaver is the most ancient living rodent and the sole survivor of a long line of primitive rodents. The Sierra Nevada mountain beaver is found near mountain streams up to 7,500 feet in elevation from the Oregon border south to the Mono Lake region. The mountain beaver is active all year and prefers riparian habitats with thick undergrowth where it builds tunnels in moist soils. This species is mostly underground in winter. Its main food items include shrubs and forbs, such as thimbleberry, blackberry, dogwood, ferns, and lupines. It mainly forages in heavy undergrowth, burrows, and on the ground surface.

Volcano Creek Golden Trout

The Volcano Creek golden trout (*Oncorhynchus mykiss aguabonita*) is a California species of special concern and a FSS species. The Volcano Creek golden trout is native to two high altitude (about 10,000 feet above sea level) watersheds in the southern Sierra Nevada. Its native range once encompassed 450 miles of stream habitat in the upper South Fork Kern River and the Golden Trout Creek tributary. This species is extremely vulnerable to hybridization with non-native rainbow trout (CGTIC 2009). Hybridization combined with other factors such as, predation by and competition for habitat with brown trout has resulted in the Volcano Creek golden trout now occupying less than 10 percent of its original range. Preferring meandering streams with sparse riparian vegetation, this species thrives in cold, clear waters with substrates composed of cobble, gravel, and sand. Favorable reaches include pools with undercut banks and aquatic vegetation (U.C. Davis 2010).

Lahontan Cutthroat Trout

Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) is a federal threatened species. This cutthroat trout is found in a variety of cold-water habitats, such as large terminal alkaline lakes (e.g., Pyramid and Walker lakes), alpine lakes (e.g., Lake Tahoe and Independence Lake), slow meandering rivers (e.g., Humboldt River), mountain rivers (e.g., Carson, Truckee, Walker, and Marys Rivers), and small headwater tributary streams (e.g., Donner and Prosser Creeks). General habitat requirements include cool flowing water with well-vegetated and stable streambanks for cover, stream velocity breaks, and relatively silt-free, rocky riffle-run areas. The Lahontan cutthroat trout is native to the Lahontan basin of northern Nevada, eastern California, and southern Oregon. In 1844, there were 11 lake dwelling populations and 3,600 stream miles were occupied. Currently, self-sustaining populations only occur in approximately 10 percent of the historic stream habitats and 0.4 percent of the historic lake habitats (USFWS 2010b).

McCloud River Redband Trout

The McCloud River redband trout (*Oncorhynchus mykiss* spp. 2) is a California species of special concern and a FSS species. The species is restricted to Shasta-Trinity National Forest (Figure 16) and the headwaters of the McCloud River by geographic features including the upper and middle falls of the McCloud River. The McCloud River redband trout’s survival is threatened by hybridization with introduced rainbow trout and environmental damage associated with logging operations. This trout is tolerant of low-flow streams and habitat preferences are variable, but for the small streams near Project trails, the redband trout habitat is limited by stream size, steep gradient, or low stream flows. Riffles and flat-water areas are the most abundant habitat types in these smaller streams (USFS 1998).

Spring-Run Chinook Salmon

On the Pacific coast, there are 17 distinct groups, or Evolutionarily Significant Units (ESUs) of Chinook salmon (*Oncorhynchus tshawutscha*). California’s Central Valley spring-run ESU is a federal threatened species. Chinook salmon are anadromous; migrating adults travel from the ocean to the freshwater streams and rivers of their birth where they spawn and die. The Central Valley spring-run population currently exists in a very small portion of its range having lost 70-

90 percent of its former spawning and rearing habitats. The average yearly abundance is 8,500 fish, whereas in the 1940s, 40,000 Chinook salmon were observed. Within the Project Area, spring-run Chinook salmon spawning habitat is found on Lassen National Forest in Mill Creek and Deer Creek between the Morgan Summit and Jonesville trail systems (Figure 18).

Yosemite Toad

The Yosemite toad (*Anaxyrus canorus*) is a federal candidate for listing under the ESA, a California species of special concern, and a FSS species. The Yosemite toad is only active a few months out of the year. The activity period ranges from April-July to late September or early October. After breeding in shallow pools and the margins of lakes or streams, males and females move from the breeding site to meadows where they feed for two to three months before the snows return. During winter, Yosemite toads shelter in rodent burrows, willow thickets, forest edges adjacent to meadows, and in clumps of vegetation near water. Native to California, the Yosemite toad is found at high elevations in the Sierra Nevada, from the Ebbets Pass area of Alpine County south to the Spanish Mountains in Fresno County (Figures 26, 28, and 30). It has been estimated that the Yosemite toad has disappeared from over 50 percent of its historic range. The causes of the decline are unclear. Disease, degradation of habitat by grazing livestock, increased ultraviolet radiation, introduced predatory fishes, a severe 1980's drought, windborne pesticide contamination, and increased predation by common ravens, whose population has increased greatly due to human activities, are all causes thought to have contributed to the decline (California Herps 2010).

Sierra Nevada Yellow-legged Frog

The Sierra Nevada yellow-legged frog (*Rana sierra*) is federal candidate for listing under the ESA, a California species of special concern, and a FSS species. The Sierra Nevada yellow-legged frog inhabits high elevation (900 to over 12,000 feet) lakes, ponds, meadow streams, isolated pools, and sunny riverbanks in the Sierra Nevada. This species hibernates at the bottom of the frozen waters during the winter months. Mating and egg-laying occur shortly after the snow melts and adults have emerged from hibernation, which can be anytime between May and August. This species' current range extends from Plumas National Forest south to Inyo National Forest (Figures 20 through 28). Absent from a large portion of its range, the decline has been attributed to many factors, including introduced non-native trout, airborne pollution, cattle grazing, ozone depletion, mining pollution, public dumping, and chytrid fungus (California Herps 2010).

Foothill Yellow-legged Frog

The foothill yellow-legged frog (*Rana boylii*) is a California species of special concern and a FSS species. The foothill yellow-legged frog typically inhabits perennial streams and ephemeral creeks that retain pools throughout the summer. This frog occupies streams associated with a variety of upland habitats including foothill hardwood, foothill hardwood-conifer, mixed conifer, chaparral, and coastal scrub (Seltenrich and Pool 2002). Historically, the foothill yellow-legged frog's range in California extends along the Coast Ranges from Oregon south to the San Gabriel River drainage in Los Angeles County and along the western slopes of the Sierra Nevada. Currently, this frog is no longer found south of Monterey County (California Herps 2010). The elevational range extends from near sea level to 5,000 feet (Seltenrich and Pool 2002). Isolated populations are found near Project trails on Lassen, Plumas, and Tahoe National Forests (Figures

18, 20, and 22). The foothill yellow-legged frog is absent from approximately 66 percent of its former habitat in the Sierra Nevada, especially south of Interstate 80 where it is mostly extinct (California Herps 2010). Habitat loss, introduced fish, disease, stream alteration from dams, mining, logging, and grazing are all serious threats to this frog.

Cascades Frog

The Cascades frog (*Rana cascadae*) is a California species of special concern and a FSS species. The Cascades frog inhabits wet mountain areas in open coniferous forests to near timberline, including small streams, small pools in meadows, lakes, bogs, ponds, and marshy areas near streams from 750 to around 9,000 feet. Historically, this frog was found in fragmented populations in northern California from the slopes of Mt. Shasta to Plumas National Forest (Figures 16, 18, and 20). The Cascades Frog is no longer present in approximately 50 percent of its historical range in California, and has disappeared from as much as 99 percent of its southernmost California populations, including Mt. Lassen, where they were once abundant (the majority of the occurrences on Figure 18 are pre-1975). Introduced sport fishing, environmental pollution, solar UV-B radiation, fungal pathogens, and loss of open meadow habitat due to fire suppression have all been suggested as factors contributing to the decline of Cascade Frogs in California (California Herps 2010).

Western Tailed Frog

The western tailed frog (*Ascaphus truei*), also known as the Pacific tailed frog is a California species of special concern. The western tailed frog inhabits cold, clear, rocky streams in wet forests. A rocky streambed is necessary for cover for adults, eggs, and larvae. Adults are active from April to October. This species ranges from near Anchor Bay in Mendocino County to Shasta-Trinity National Forest. The two occurrences on Figure 16 appear to be the easternmost occurrences reported. Those occurrences date from 1989. Sedimentation and warmer stream temperatures have been proposed as possible causes of this species' decline (California Herps 2010).

Sierra Madre Yellow-legged Frog

The Sierra Madre yellow-legged frog (*Rana muscosa*) is a federal endangered species, a California species of special concern, and a FSS species. In the southern Sierra Nevada Mountains, the Sierra Madre yellow-legged frog inhabits lakes, ponds, meadow streams, and isolated pools, along sunny riverbanks in montane riparian, lodgepole pine, subalpine conifer, and wet meadow habitats. Reproduction does not take place until lakes and streams are free of ice. The distribution of this species in the Sierra Nevada is limited by the eastern crest of the Sierra Nevada; no populations occur east of the crest. This species was once known as the mountain yellow-legged frog, populations north of a ridge dividing the middle and south forks of the Kings River are now considered the Sierra Nevada yellow-legged frog. The decline of the Sierra Madre yellow-legged frog has been attributed to many factors, including bullfrogs, introduced non-native trout, airborne pollution, cattle grazing, ozone depletion, mining pollution, off-road vehicle disturbance, public dumping, chytrid fungus, fires, and excessive flooding. (California Herps 2010).

Mount Lyell Salamander

The Mount Lyell salamander (*Hydromantes playcephalus*) is a California species of special concern. This salamander is nocturnal, cold-tolerant, and inhabits caves, granite exposures, rock fissures, and seepages from springs and melting snow. This species is found between 4,000 and 12,000 feet in elevation and ranges from the Sonora Pass south to the Franklin Pass area in Tulare County (California Herps 2010). Much of their range lies in Wilderness Areas and Yosemite National Park so there are few threats from human activities (Wake and Papenfuss 2005). In the Project area, the Mt. Lyell Salamander has been observed near Inyo OSV trails (Figure 28).

5.3 PROJECT IMPACTS

5.3.1 Thresholds of Significance

The following thresholds of significance are adapted from Initial Study Checklist included in the CEQA Guidelines Appendix G. A project would have a significant biological impact if it would:

- Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by CDFG or USFWS;
- Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by CDFG or USFWS;
- Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means;
- Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites;
- Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance;
- Conflict with the provisions of an adopted HCP, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

Biological resources in the Project Area are located in national forests. There are no local policies, ordinances, adopted habitat conservation plans, or natural community conservation plans in effect within the Project Area.

5.3.2 Project Baseline, Year 2010

5.3.2.1 Special-Status Wildlife

For any project, managers of wildlife are concerned with general habitat protection, management, and enhancement; protection of breeding activity; minimizing effects on common wildlife; and maintaining wildlife corridors and connectivity to promote genetic diversity. Recreational activities (motorized and non-motorized) can alter wildlife behavior, cause wildlife displacement from preferred habitat, and decrease reproductive success and individual vigor (as discussed below). The OSV Program could have both direct and indirect impacts on wildlife. These impacts are associated with vehicle collision, home range use, breeding, physiological stress, opening corridors for predators that would not ordinarily be available, and snow compaction, are described below. It is possible that OSV use would have a greater impact on wildlife during severe winters when wildlife is already stressed by environmental conditions. As noted in the Project Description, project trail grooming occurs on minimum snow depths of 12 inches. Trail grooming generally occurs at night between dusk and sunrise. Popular trails may be groomed several times per week, while other trails may be groomed only once per week. Some species or individuals become habituated to OSV activities (i.e., the animal decreases or stops its response to a repetitive stimulus that neither rewards nor harms the animal). Habituation is a variable phenomenon among wildlife species (Knight and Gutzwiller 1995) with some species, or some individuals within a species, habituating to certain circumstances but not others (e.g., white-tailed deer (*Odocoileus hemionus*; Moen et al. 1982 in Zielinski et al. 2007).

The 11 national forests included in the Project Area use a range of management tools to provide quality habitat for all wildlife species, common and special-status; these are described in the LRMPs for each forest (see Land Use Plans and Policies, Section 4.0 and LRMP policies in Appendix D). For example, the Klamath National Forest closes roads when necessary to limit activities that inhibit mule deer use of quality foraging, fawning/rearing, or wintering areas, and it maintains or establishes roadside screening along open roads in areas important for migration, fawning/rearing, or concentrated seasonal use. Key winter and spring use areas are managed to provide a good forage to cover habitat ratio for mule deer. USFS forest-wide S&G s and management prescriptions identified in Appendix D are taken into account in the following impact analysis.

<u>Vehicle Collision</u>. The likelihood of a collision between snow grooming equipment and wildlife is extremely low because the equipment travels slowly (3 to 6 mph). There is an increased likelihood of collision with OSVs due to higher frequency of OSV use and higher speeds. Vehicle collision with a mammal would result in an adverse impact to that particular animal, but is assumed to be so rare in occurrence that it would not significantly affect the population, even in the event that the mammal was a special-status species. Sensitive habitat areas such as known denning sites are identified through surveys and monitoring and are closed to OSV use (Table 5-5). Because vehicle collision would not have a substantial adverse effect on a species population either directly or through habitat modifications, it is considered a less-than-significant impact.

<u>Home Range Use</u>. Noise and extended human presence from OSV activities could reduce the size of the winter home range for several wildlife species. The home range provides food, shelter, and breeding opportunity, and if it is reduced, could compromise species survival, particularly during stressful survival conditions in the winter. Trail grooming activities occur at night, are infrequent, and move slowly enough that grooming is not expected to have a substantial adverse effect on wildlife home range. Many of the species that may be active or present during the OSV Program season are nocturnal and may not be affected by daytime snowmobile activities at all; however, 29 percent of snowmobilers report some nighttime riding (Project Description, Table 2-9). This can include daytime riders who do not return to the trailhead before early nightfall and those that ride in late night hours. For diurnal species, OSV use of the trails may result in animals avoiding areas used by snowmobilers. For nocturnal and crepuscular species trail grooming and OSV use may also result in animals avoiding areas frequented by snowmobilers and groomers. The continued funding of the Program would not change the extent of existing effects; however, with the anticipated increase in riders accessing the backcountry, extended human disturbance may reduce the home range for special-status wildlife species. The impact by the OSV Program is not considered to have a substantial adverse effect on common species' populations or home range use either directly or through habitat

modifications. However, an adverse impact may be felt by special-status species already pressured by existing forest uses and by an increase in riders. The national forests operating under the OSV Program operate under numerous Land Resource Management Plan policies (Appendix D) that address this issue and mitigate any substantial adverse impact to less than significant.

Breeding Disruption. If the winter season overlaps with the beginning of breeding season as may be the case for species such as the yellow-bellied marmot and other birds and mammals, the presence of OSVs in the forests could disrupt courtship and nesting or denning activities due to noise and/or visual disturbance that result in behavioral changes in the animals. This ongoing impact, along with the anticipated increase in riders over the next 10 years, may have a minor to moderate effect on common species as it would affect individuals, but it would not affect the viability of common wildlife species' populations. For special-status species, breeding disruption could be a significant adverse impact to a species with an already low population. With the implementation of the Management Actions already in use (Table 5-5) by the national forests and Mitigation Measures BIO-1 and 2 identified below in Section 5.4, the project impacts during early courtship and nesting/denning periods would remain at existing levels. No new impacts would occur as a result of the continuation of the OSV Program and therefore, the Project's effect on special-status birds is less than significant.

Physiological Stress. Single or repeated interactions between OSVs and wildlife could lead to energy expenditures from flight or vigilance reactions. Mammals, birds, and fish may experience an elevated heart rate and metabolism resulting in high energy expenditures, elevated production of stress hormones (i.e., glucocorticoids), increased susceptibility to predation, decreased reproduction, and diminished nutritional condition (NPS 2007). The energetic cost of flight can be significant for predatory animals. Quantifying these physiological responses in wildlife is extremely difficult.

The grooming equipment operates infrequently and moves slowly, so it is estimated that it results in fewer flight or vigilance reactions. Grooming is not expected to have a substantial adverse effect on wildlife populations as a result of physiological stress. Snowmobile use likely results in more flight or vigilance reactions because there are more vehicles, they move faster, and they are generally louder than grooming equipment. It is assumed that an individual animal is unlikely to have repeated encounters with OSVs as encounters would likely result in animals avoiding trail areas (NPS 2007). Physiological stress may impact individuals, but given that only some individuals from a population may not even travel within the Project Area affected by the OSV Program, the effect to populations is expected to be negligible to minor and is thus less than significant.

Coyote Incursion. Packed trails resulting from snowmobile use facilitate coyote incursion into deep snow areas (Bunnell et. al. 2006) and can adversely impact marten or other mammal populations through increased competition and predation. A study in Utah found that 90 percent of coyote movement was made within 1,150 feet of packed trails (Bunnell et. al. 2006). Competition and predation, if occurring, would be predictably restricted to areas in the immediate vicinity of trails. The use of OSV trails and regular grooming is an existing condition that has been in operation for numerous years; and no new trail expansion is proposed at this time. Therefore, coyote incursion, if occurring, would continue, but would not be increased by OSV Program activities.

Snow Compaction. Mechanical snow compaction changes water content and the rate of spring-melt-off, reduces snow depth, and increases thermal conductivity and snow density to a point where subnivean fauna (small mammals that live under the snow in winter such as shrews, voles, pocket gophers, and mice) could not move in the small spaces between the ground and the snow (Brander 1974). Snow compaction may impact individuals, but given that small mammals' population densities are dependent on numerous factors, and only some individuals from a population may even be affected by snow compaction, the effect to populations is not considered significant.

Deer. Wintering deer are sensitive to disturbances of all kinds. Both snowmobiles and cross-country skiers are known to cause wintering ungulates to flee (Freddy et al. 1986). Dorrance et al. (1975) found that snowmobile traffic resulted in increased home range size, increased movement, and displacement of deer from areas along trails. Direct environmental impacts of snowmobiles include collisions causing mortality and harassment that increased metabolic rates and stress responses (Canfield et al. 1999 in NPS 2007).

The majority of groomed trails in the Project Area do not cross deer winter habitat; Tahoe National Forest's China Wall trailhead is the only exception (Figure 22). In addition, the Big Creek trailhead at Bucks Lake and portions of the La Porte trail system on Plumas National Forest (Figure 20) are adjacent to mule deer winter range and portions of Sequoia National Forest's groomed trails are within or less than a mile from winter range. The Tri-Forest and Tahoe National Forests' snowmobile routes travel through several sections of known mule deer fawning grounds. Fawns are born from early April to mid-summer, varying geographically so fawning season could overlap with a late snowmelt. The USFS monitors deer populations and, in general, sites most OSV trails away from winter range in order to lessen the impacts on deer. When activities affect deer's use of quality foraging, fawning/rearing, or wintering areas, national forests use a variety of techniques for protecting these areas including road and OSV trail closure (Appendix D). With these management policies in place the effect of the OSV Program on deer populations is not significant.

Birds. Proposed trail grooming would not adversely affect most wildlife active in the Project Area in winter (Table 5-4) because it occurs on existing roads and trails and primarily occurs at night when fewer species are active. Trail grooming would not modify habitat. In some years, there is a possibility that an extended snow season would overlap with the start of the breeding season for some birds. Noise disturbance in proximity to nesting birds may lead to nest abandonment and/or reproductive failure. However, due to the nighttime operating hours and the limited frequency and duration of trail grooming at any trail segment location, as well as the grooming activity being an ongoing operation for many years on the same trail routes, the noise disturbance from trail grooming would not have a substantial adverse effect on nesting birds.

The proposed OSV Program funding would facilitate the continuation of existing OSV use levels on project trails. OSV use occurs mostly in daylight hours potentially every day of the week with the heaviest use occurring on weekends and holidays; however, night riding can also occur on any of the trails. OSV use in the Project Area late in the snow season may cause noise disturbance to courting or nesting birds and cause decreased reproductive success. If an extended snow season overlaps with the start of the breeding season, noise disturbance in proximity to nesting birds may lead to nest abandonment and/or reproductive failure. The likelihood of affecting nesting birds is rare; for most species, nesting occurs after the snow season has ended. Given the potential for multiple occurrences of OSV use throughout each day, noise disturbance may have a minor to moderate adverse effect on special-status bird individuals, such as bald eagle, American peregrine falcon, northern spotted owl, and golden eagle. Where nest sites are known to occur within ¼ mile of a trail, the national forests implement LOPs or trail closures during the breeding season (Table 5-5). Nest checks are performed annually by national forest personnel to confirm that known nest sites remain active and successful. With the implementation of the Management Actions already in use by the national forests, the project noise impacts to birds during early courtship and nesting periods would remain at existing levels. No new impacts would occur as a result of the continuation of the OSV Program and therefore, the Project's effect on special-status birds is less than significant.

Bald Eagle

Studies in Yellowstone National Park showed bald eagle response to snowmobiles depended on distance from road, interaction time, human behavior, and habitat. These studies also indicated that successful nesting and fledging could not be correlated with cumulative OSV traffic (NPS 2007). In the low snow-fall years when snowmobilers have access to lakes that are beginning to melt out, OSV use may have an impact on bald eagle foraging success. However, bald eagles are known to forage on lakes with power boats, and may not be adversely affected by snowmobile noise or activity.

In Inyo, Modoc, and Plumas National Forests, the USFS annually checks historic bald eagle nests within ¼ mile of groomed trails for presence and nesting activity. No significant effect on bald eagle from OSV activity has been determined. With this USFS Management Action in effect (Table 5-5) the project impact to bald eagle is considered less than significant.

Northern Goshawk

For northern goshawk, occurring on all national forests in this study, noise disturbance during breeding activity is the primary concern. Breeding territories and protected activity centers present within ½ mile of snowmobile routes are monitored for occupancy, nesting status, and reproductive success. In addition, a LOP within ¼ mile of a nest is imposed beginning February 15th. With the continued implementation of this USFS Management Action, (Table 5-5) the project impact to northern goshawk is considered less than significant.

The USFS Pacific Southwest Region has been conducting a study to further evaluate potential effects of OHV/OSV activity on northern goshawk. This study, conducted on the Plumas National Forest, evaluates OHV/OSV use and noise around northern goshawk nests and nest stands and uses experimental manipulations designed to evaluate the bird's sensitivity to direct disturbance by OHV/OSVs during the nesting, post-fledging, and winter (non-breeding) seasons. The study will estimate the relationship between goshawk reproductive success, post-fledging survival rates, nesting behavior, and likelihood of nesting relative to OHV/OSV use and noise. The Regional Northern Goshawk Focused Study is expected to be completed in 2010. At the time of this EIR, the study has not been published.

As discussed above, based upon the data available to date, the current USFS northern goshawk management action (monitoring and LOPs) is adequate to ensure the impacts of the OSV Program on northern goshawks are less than significant. Since the USFS continues to study the species, however, this EIR takes an adaptive management approach to mitigation. Based upon the results of the Regional Northern Goshawk Focused Study, biologists may revise the USFS northern goshawk management action. Measure BIO-1 thus requires the USFS to report any changes in the USFS northern goshawk management action to the OHMVR Division for incorporation into the OSV Program contract requirements. Revisions to the management action, such as new LOPs or trail closures, would be sufficient to continue to address any adverse effects to goshawks from OSV activities and would ensure that the impact to goshawks remain at a less-than-significant level.

California Spotted Owl, Northern Spotted Owl, Great Gray Owl

Trail grooming and night riding could disturb owls that forage at night. The passage of a trail grooming machine or an OSV may interrupt owl foraging, result in owl prey taking refuge, or cause owls to redirect their foraging away from trail areas. Trail grooming impact on owl foraging is negligible due to the limited frequency of trail grooming and the short presence of the grooming machine at any trail segment location.

The great gray owl could potentially be affected by OSV activities. Snowplay in meadows may disrupt foraging activities or prey base; however the great gray owl's occurrence is rare at high elevations and breeding and foraging generally occur below snowline in the Sierra Nevada. Noise that disturbs breeding is the primary potential conflict. Effects are likely to be minimal due to limited overlap of breeding (March) and the nocturnal nature of owls. Disturbance depends upon proximity of snowmobile use within ¼ mile of nests. An LOP on groomed trails within ¼ mile of PACs is imposed beginning March 1 on those national forests with known presence – Sequoia, Sierra, and Stanislaus. With the continued implementation of this USFS Management Action (Table 5-5), the project impact to the great gray owl is considered less than significant.

California spotted owls face the same potential disturbances as the great gray owl. Those national forests with known presence, Eldorado, Lassen, Plumas, Sequoia, Sierra, Stanislaus, and Tahoe, monitor California spotted owl PACs. LOPs on groomed trails are imposed within ¼ mile of PACs after March 1. With the continued implementation of this USFS Management Action (Table 5-5) the project impact to the California spotted owl is considered less than significant.

Similar to the great gray owl and California spotted owl, the northern spotted owl could potentially be affected by OSV activities. Where the northern spotted owl occurs on the Klamath, Modoc, and Shasta-Trinity National Forest, monitoring of spotted owl PACs occur every year and LOPs on groomed trails within 1/4 mile of PACs are imposed after February 15. With the continued implementation of this USFS Management Action (Table 5-5) the project impact to the California spotted owl is considered less than significant.

The USFS Pacific Southwest Region has been conducting a study to further evaluate potential effects of OHV/OSV activity on northern spotted owls. The objectives of this study, conducted on the Shasta-Trinity and Mendocino National Forests, are to: 1) describe northern spotted owl stress levels, behavior, and nesting success and OHV use at selected northern spotted owl nest and/or roost sites over time; 2) determine whether OHV use affects northern spotted owl stress levels, behavior, or nesting success, and, whether observed effects vary with reproductive state over time; and, 3) determine the need for disturbance-specific management considerations to minimize potential adverse effects of OHV use on spotted owls that reside on national forest system lands. Final data analysis for the northern spotted owl study has been completed and is undergoing final review prior to publication. The Northern Spotted Owl Focused Study is expected to be completed in 2010. At the time of this EIR, the study has not been published.

As discussed above, based upon the data available to date, the current USFS northern spotted owl management action (monitoring and LOPs) is adequate to ensure the impacts of the OSV Program on northern spotted owls are less than significant. Since the USFS continues to study the species, however, this EIR takes an adaptive management approach to mitigation. Based upon the results of the Northern Spotted Owl Focused Study, biologists may revise the USFS northern spotted owl management action. Measure BIO-1 thus requires the USFS to report any changes in the USFS northern spotted owl management action to the OHMVR Division for incorporation into the OSV Program contract requirements. Revisions to the management action, such as new LOPs or trail closures, would be sufficient to continue to address any adverse effects to northern spotted owls from OSV activities and would ensure that the impact to goshawks remain at a less-than-significant level.

American Peregrine Falcon

Due to its breeding success and subsequent removal from the federal endangered species list, the peregrine falcon is a low monitoring priority for the USFS. Noise disturbing breeding activity is the primary potential conflict. If nests are active early in the season while OSV activity still occurs, the USFS generally enacts at least ¼ mile closures surrounding the nest (Table 5-5). With the continued implementation of this USFS Management Action (Table 5-5) the project impact to the American peregrine falcon is considered less than significant.

California Condor

Potential nesting habitat for California condor exists within the Giant Sequoia National Monument; however nesting has yet to occur there. Female condors lay eggs in February or March, so there is the possibility of overlapping with OSV activity as well as the possibility of nesting behavior being disrupted by human intrusion. If a female condor does nest, the management direction from the USFWS includes trail closure around the nest grove and potential nest trees if condors are in the area and possibly looking for a nest site during the breeding season. For this reason, coupled with no OSVs allowed off-trail within the National Monument, the impact of the OSV Program to the California condor and its critical habitat is considered less than significant.

American Marten

A recent study on the effect of OHV/OSV use on American martens found that martens were pervasive in both OHV/OSV use and non-use areas; occupancy and probability of detection appeared to be unaffected (Zielinski et. al. 2007). As OSV trail use is an existing condition, animals that occur in the areas affected by the OSV Program during winter may be habituated to OSV disturbance or may have already modified their behavior to avoid trail areas. Night riding has the potential to affect nocturnal animals like the marten. OSV noise resonating in the forest may cause an alert or startle response in individual animals or may be accepted as ambient noise conditions of the environment as suggested by the study on American martens (Zielinski et al. 2007) even though that study concluded that martens appear to be unaffected by snowmobile recreation. Zielinski et al. 2007 acknowledged the limits of their study by saying, “We did not, however, measure behavioral, physiological, or demographic responses, so it is possible that OHV/OSVs may have effects, alone or in concert with other threats (e.g., timber harvest) that were not quantified in this study.” Several national forests that are involved with the OSV Program implement management measures to protect martens. Inyo, Plumas, Sequoia, Shasta-

Trinity, Sierra, Stanislaus and Tahoe National Forests implement LOPs or enforce trail closures within ¼ mile of identified den sites if martens appear to be affected and install restrictive signs in areas prone to illegal off-trail use. Klamath National Forest provides informational and educational materials to prevent harassment of wildlife and patrols trails with USFS or snowmobile club personnel. With these existing management measures in effect, the OSV Program's effect on marten is considered less than significant.

Pacific Fisher

The USFWS (2004) concluded that, "vehicle traffic during the breeding season in suitable habitat may impact foraging and breeding activity" and that "hiking, biking, OHV and snowmobile trails, may adversely affect fishers." In winter, fishers occur at elevations lower than the heaviest snowfalls (greater than 5 or 6 inches; Krohn et al. 1997) and would not be expected to be present during snowmobile activities. The USFS continues to monitor for presence of Pacific fisher (Table 5-5). LOPs on groomed trails are established within ¼ mile of known den sites after March 1. With the continued implementation of this USFS Management Action (Table 5-5) the OSV Program impact to the Pacific fisher is considered less than significant.

California Wolverine

The California wolverine has not been detected in the Project Area during winter for decades and none of those sightings occurred within a groomed trail corridor. A recent wolverine sighting occurred north of Truckee at a camera tracking station operated by the Pacific Southwest Research Station. DNA testing revealed that the wolverine did not match the California population but has a genetic type that is found throughout the Rocky Mountains, Alaska, and Canada (Science Daily 2008). Wolverines appear to select areas that are free from significant human disturbance, especially during the denning period from late winter through early spring. (Carroll et al. 2001). Highly secretive animals such as the wolverine are likely to avoid any areas of human presence and thus are not likely subject to adverse effects from OSV activity. However, most researchers agree that adult females, particularly during the natal denning period (January to April) are highly sensitive to disturbance (Banci 1994).

California wolverine is not expected to be present; however, if present, snowmobile activity around a natal den could create a significant impact by stressing and increasing energy expenditures of female wolverines and result in incidental mortality of offspring due to den abandonment possibly resulting in population-level impacts (Banci 1994). The USFS includes wolverine in its annual carnivore monitoring: Sierra National Forest enforces a LOP from March 1 through June 30 if monitoring determines that OSV activities are causing noise disturbance to wolverine, and Plumas National Forest implements trail closures and rerouting of selected portions of OSV trails if disturbance is identified through the monitoring process. Mitigation Measure BIO-2 incorporates management measures to be taken if monitors on other OSV Program national forests discover natal denning sites. These measures include route closures and/or LOPs surrounding den sites. With this measure in place, the Project's potential effect on California wolverine would be less than significant.

Sierra Nevada Red Fox

Little information exists on the distribution and ecology of the Sierra Nevada red fox in California (Perrine et al. 2010). Over the last 20 years, it has been predominantly found in and surrounding Lassen Volcanic National Park, including occurrences at the Morgan Summit trailhead and the Swain Mountain trailhead (Perrin 2005). There are incidental sightings, however, within or adjacent to other snowmobile trail systems (Sierra National Forest WHPP), as well as the recent sighting on the Humboldt-Toiyabe National Forest near Sonora Pass (USFS 2010). The USFS has announced that wildlife biologists from the USFS, CDFG, and the University of California, Davis, will set-up additional monitoring stations to gather more information on the presence of Sierra Nevada red fox in the area of Sonora Pass.

The effects of OSV/OHV activity on this species have not been studied, but noise and extended human presence from OSV use has the potential to significantly impact nocturnal animals like the red fox through direct collisions, disruption of breeding activities, and reduction in home range use. It has also been reported that begging behavior has occurred at Lassen National Forest snowmobile trailheads (Perrine 2005). Increased exposure to humans, vehicles, and pets increases undesirable behaviors on the part of foxes and increases their exposure to disease transmitted from pets. Measure BIO-3 requires Lassen National Forest to provide educational materials on red fox and the importance of minimizing direct contact with red foxes.

Two national forests include the red fox in their annual carnivore monitoring: Sierra National Forest enforces a LOP from March 1 through June 30, if monitoring determines that OSV activities are causing noise disturbance to red fox; and, Plumas National Forest implements trail closures and rerouting of selected portions of OSV trails if disturbance is identified through the monitoring process.

Measure BIO-3 addresses known potential impacts within the Lassen National Forest and requires the USFS to conduct an inventory of the Sierra Nevada red fox in order to refine occurrence data with the Project Area. Measure BIO-3 also incorporates management measures to be taken if monitors on other OSV Program national forests determine that OSV activities are disturbing red fox affecting behaviors. While the recent sighting of a red fox occurred on a the Humboldt-Toiyabe National Forest which is not part of the OSV Program, the sighting occurred in the vicinity of Stanislaus National Forest near the OSV Program Project Area. Measure BIO-3 requires the USFS to provide the results of their new inventory and monitoring in the area to the OHMVR Division as it becomes available. Continued implementation of the USFS management actions within the Sierra and Plumas National Forests, in conjunction with the mitigation in Measure BIO-3, would ensure the impacts of the OSV program on the Sierra Nevada Red Fox are less than significant.

Mountain Lion

Mountain lions can be found throughout California, but are closely associated with mule deer and mule deer migrations. Only the China Wall trailhead is located within wintering deer habitat. Mountain lions generally are active and hunt at night; consequently, the likelihood of OSVs encountering a mountain lion diminishes as only 29 percent of riders report night riding. Potential impacts could include direct vehicle collision and indirect physiological stress. These are considered unlikely and less than significant as the primary threat to mountain lions in California is degradation of its habitat. With the ongoing implementation of the Management Actions already in use by the national forests of siting snowmobile trails away from mule deer winter range, the Project’s impacts to mountain lions would remain at existing less than significant levels. No new impacts would occur as a result of the continuation of the OSV Program and, therefore, the Project’s effect on mountain lions is considered less than significant.

Sierra Nevada Snowshoe Hare

Potential direct impacts to the Sierra Nevada snowshoe hare include vehicle collisions; indirect impacts include fragmented habitat, physiological stress, and displacement from home ranges. Sierra Nevada snowshoe hares rarely leave the security of dense brush, places OSVs and grooming equipment avoid. In addition, lagomorphs (hares, rabbits, and pikas) have been found to avoid trails in order to avoid predators (Neumann and Merriam 1972). Small mammals' population densities are dependent on numerous factors, and only some individuals from a population may be affected by OSV activities. For these reasons, the Project's effect on Sierra Nevada snowshoe hare populations is considered less than significant.

Western White-tailed Jackrabbit

Potential direct impacts to the western white-tailed jackrabbit include vehicle collisions; indirect impacts include fragmented habitat, physiological stress, and displacement from home ranges. In winter, white-tailed jackrabbits avoid open areas and prefer dense thickets for hiding and resting; these dense thickets are places OSV riders generally avoid. In addition, lagomorphs (hares, rabbits, and pikas) have been found to avoid trails in order to avoid predators (Neumann and Merriam 1972). Small mammals' population densities are dependent on numerous factors and only some individuals from a population may be affected by OSV activities. For these reasons, the Project's effect on western white-tailed jackrabbit populations is considered less than significant.

Mount Lyell Shrew

Potential direct impacts to the Mount Lyell shrew include vehicle collisions; indirect impacts include snow compaction, physiological stress, and displacement from home ranges. Mount Lyell shrews avoid open areas and prefer dense riparian areas with moist soils near fast moving water, places OSV riders generally avoid. Small mammals' population densities are dependent on numerous factors, and only some individuals from a population may be affected by OSV activities. For these reasons, the Project's effect on Mount Lyell shrew populations is considered less than significant.

American Badger

Potential direct impacts to the American badger include vehicle collisions; indirect impacts include physiological stress and displacement from home ranges. The American badger spends most of the winter in a state of torpor (not true hibernation), and the likelihood of encountering one during OSV Program activities is rare. Small mammals' population densities are dependent on numerous factors, and only some individuals from a population may be affected by OSV activities. For these reasons, the Project's effect on American badger populations is considered less than significant.

Sierra Nevada Mountain Beaver

Potential direct impacts to the American badger include vehicle collisions; indirect impacts include physiological stress and displacement from home ranges. The Sierra Nevada mountain beaver spends most of the winter underground, so encountering this species would be very rare. Small mammals' population densities are dependent on numerous factors, and only some individuals from a population may be affected by OSV activities. For these reasons, the Project's effect on Sierra Nevada mountain beaver populations is considered less than significant.

Fish and Amphibians

Direct impacts to fish and amphibians would be extremely rare as amphibians hibernate during the winter, and OSVs would have to travel through water to collide with fish. Due to the rarity of this occurring, the direct impacts to fish and amphibians are considered less than significant.

Potential indirect impacts include impaired water quality. Impacts to water quality are assessed in Hydrology, Section 6.0. Based on multi-year studies in Yellowstone National Park, researchers concluded that Yellowstone OSV use levels have not resulted in impaired water quality. Given that OSV use levels at OSV Program trailheads is less than OSV use levels occurring at Yellowstone during the study period, it is determined that water quality is not impaired by the OSV Program (Hydrology, Section 6.3.3). For this reason, negative impacts on special-status fish and amphibians due to impaired water quality are considered less than significant.

5.3.2.2 Special-Status Plants

In most of the 11 national forests in the Project Area, grooming of trails would occur only when there is at least 12 inches of snow on the ground (Eldorado, Stanislaus, and Inyo National Forests require a minimum of 18 inches, and Sequoia National Forest requires a minimum of 24 inches). These routes are used all year, and plants do not grow on the paved and gravel roads and dirt trails comprising the groomed trail system. If plants were to take root along these routes, the 12 inches of snow would protect them from grooming. Therefore, special-status plant species and their habitat are not impacted by trail grooming.

Although most national forests do not have minimum snow depth requirements for OSV users, OSV users generally favor deep snow conditions because traveling on dirt or pavement can cause severe damage to snowmobiles. Low snow conditions on the groomed trail systems do not pose a threat to special-status plants because the groomed trails mainly occur over existing roads (either dirt based or improved road surfaces) or OHV trails which do not contain special status plants. However, snowmobiles in off-trail or open riding areas during low snow conditions can potentially damage special-status plant populations and associated habitats. Impacts can range from destroying seeds and trampling and breaking seedlings or saplings, to destroying growing medium and even to enhancing habitat (for plants that prefer disturbance). The special-status plants listed in Appendix F and Table 5-2 are comprised of annuals and perennials. Both annual and perennial special-status plants could be impacted if OSVs traveled over bare ground or in areas with low-snow conditions.

Lassen and Inyo National Forests monitor snow depths (Inyo) or after snow melt (Lassen) and inspect for damage to four FSS species that are also California rare plant ranked species (Table 5-3). Both national forests take corrective actions (signage, barriers, etc.) if necessary. Inyo National Forest works with OSV outfitters to educate users regarding snow conditions and appropriate use areas. While the potential special-status plant impacts by the OSV Program grooming activity and subsequent OSV use are very low, impacts could occur if off-trail snowmobile use crosses the habitat of these species when the snowpack is minimal and over bare ground. All the national forests involved with the OSV Program manage and conserve federal special-status plant species and their habitats to ensure viable populations are maintained.

Monitoring of federal special-status plant species occurs every season, and if adverse impacts occur, corrective actions are taken. Corrective actions may include, but are not limited to, improved trail maintenance, adjusting seasons of use, reducing OSV use, signing barriers to redistribute use, partially closing areas, rotating use, prohibiting specific vehicle types causing damage, or totally closing an area. Site conditions are monitored by USFS staff in each national forest and recorded on the OSV Program Monitoring Checklist (see Appendix C). These are submitted to the OHMVR Division for review prior to the next season's funding. The five special-status plant species for which the USFS has ongoing or recent management measures (Table 5-3) are discussed below in detail.

Mono Milk-Vetch

The Mono milk-vetch is a low-growing perennial plant, dormant in the winter and occurring in the Inyo National Forest at the Smokey Bear Flat in the Lookout Loop use area. Inyo requires a minimum of 18 inches of snow for grooming operations, and because grooming occurs on well-established routes, no impacts to Mono milk-vetch are expected from grooming. Off-trail use of snow play areas may cause occasional soil disturbance or compaction during low snow conditions. Under normal winter conditions, the majority of the pumice flat will have adequate coverage for snowmobile use, but a few isolated areas, e.g. south aspects or windblown areas, may have a very thin snow cover or be entirely exposed. Inyo National Forest works with OSV outfitters to educate users regarding snow conditions and appropriate use areas. OSVs are permitted to use these trails only when there is sufficient snow cover to protect soil and vegetative resources and the population is monitored annually. With ongoing implementation of the USFS Management Action (Table 5-3) the continuation of the OSV Program would not have a significant effect on Mono milk-vetch.

Mono Lake Lupine

Mono Lake lupine is a low-growing perennial, dormant in winter and occurring in the Inyo National Forest on pumice flats, in the same habitat association as the Mono milk-vetch, and is known to occur at Smokey Bear Flat in the Lookout Loop use area. Inyo requires a minimum of 18 inches of snow for grooming operations and because grooming occurs on well-established routes, no impacts to Mono milk-vetch are expected from grooming. Off-trail use of snow play areas may occasionally cause soil disturbance or compaction during low snow conditions. While the Mono Lake lupine may tolerate disturbance, as evidenced by its occurrence along roads, studies indicate a decrease in plant density related to proximity to the road, and a decrease in plant vigor and plant density in off-road tire tracks (Inyo National Forest 2003 WHPP). Under normal winter conditions, the majority of the pumice flat will have adequate coverage for snowmobile use, but a few isolated areas, e.g. south aspects or windblown areas, may have a very thin snow cover or be exposed. Inyo National Forest works with OSV outfitters to educate users regarding snow conditions and appropriate use areas. OSVs are permitted to use these trails only when there is sufficient snow cover to protect soil and vegetative resources. The population is monitored annually (Table 5-3), and OSV use has not had an adverse effect on Mono Lake lupine to date. With ongoing implementation of the USFS Management Action (Table 5-3), the continuation of the OSV Program would not have a significant effect on Mono Lake lupine.

Slender Orcutt Grass

Slender Orcutt grass is an annual plant that grows at numerous locations on Lassen National Forest. Critical habitat and one occurrence are adjacent to the Jonesville trailhead. Critical habitat and a small population are also within three miles of the Bogard trail system. Because this plant is an annual, it is dormant as a seed bank in the winter and is covered by snow in OSV areas. This species inhabits open, vernal areas, which would make good “play” areas for snowmobiles. As such, concern would be for riders in low snow conditions affecting bare soils where seeds may have been deposited. Past monitoring has not indicated any OSV impacts to these occurrences or habitat. The Swain Mountain kiosk contains educational materials due to documented evidence of OHV impacts during summer activities. In 2007, Lassen National Forest determined it was no longer necessary to monitor for OSV damage because there were no observed impacts (Table 5-3). The continuation of the OSV Program would not have a significant effect on slender Orcutt grass.

Barron’s Buckwheat

Barron’s buckwheat occurs on the Lassen National Forest on minor ridge tops in sandy loam soils at a narrow elevation range of 6,600 to 6,725 feet. The occurrence adjacent to the Swain Mountain OSV route (Figure 19) has been consistently monitored every year by the USFS using the CNPS’s Botanical Survey Guidelines, and OSV damage has not been found to occur. However, the habitat for this species has topography attractive to OSV use, and damage could occur to this perennial plant under low snow conditions. Lassen National Forest monitors for damage each spring; no damage has been found. If damage were to be found, corrective actions would be taken such as trail reroutes, signage, etc. With ongoing implementation of the USFS Management Action (Table 5-3), the continuation of the OSV Program would not have a significant effect on Barron’s buckwheat.

Columbia Yellow Cress

The Columbia yellow cress occurrence (habitat and individuals) within the Bogard area of Lassen National Forest is at risk of damage if that area is used during low snow conditions. While no OSV damage has been noted in past monitoring, this occurrence is monitored during or right after snowmelt to ensure the continued viability of the occurrence and the hydrology of the playa. If damage is detected, corrective actions, such as trail closures, would be taken at that time. With ongoing implementation of the USFS Management Action (Table 5-3), the continuation of the OSV Program would not have a significant effect on Columbia yellow cress.

Additional Special-Status Plant Species

The USFS actively manages four plant species identified by the USFS as sensitive (Table 5-3). Additional federal and non-federal special-status plant species with potential to occur in the Project Area are found in Appendix F.

The potential for impacts of OSV Program grooming and subsequent OSV use on special-status plants is very low because: 1) grooming does not occur when the snowpack is less than 12 inches deep (18 inches in some locations) per USFS management practices; 2) groomed trails are typically located over unvegetated existing roads and OHV trails; and 3) snowmobilers generally avoid low snow areas and bare soil to avoid vehicle damage. However, significant impacts could occur if off-trail snowmobile use crosses the habitat of these species when the snowpack is less than 12 inches deep.

The USFS has not monitored all California rare plant ranked species because not all are federally listed or FSS species. As the proposed OSV Program is a project under CEQA review, the OHMVR Division is responsible for addressing potential impacts to other special-status plants species, such as CRPR-list 1B and 2 species that are not also federally listed or FSS species. Ongoing USFS management measures listed in Table 5-3 address known potential impacts to special-status plant species. Measure BIO-4 requires the USFS to conduct resource inventories and monitoring for fifty-three CRPR 1B and CRPR 2 species listed in Table 5-6 in order to refine occurrence data with the Project Area. The USFS shall also incorporate management measures to be taken if monitoring data determine that OSV activities are significantly impacting any of the monitored plant species. Such measures (trail reroutes, barriers, seasonal closures, signage, public education, etc.) would be specified as needed to address site-specific concerns. Until the resource inventories are completed and any necessary management strategies developed and implemented, the USFS shall also conduct public outreach with educational materials that include discussion of the hazards of riding on less than 12 inches of snow. Implementation of ongoing management actions, in conjunction with Measure BIO-4, would ensure that OSV Program impacts on special-status plants remain less than significant.

Table 5-6 CRPR 1B and CRPR 2 Plant Species to be inventoried and monitored as part of Mitigation Measure BIO-4

National Forest	Special-status Plant Species
Klamath	Newberry's cinquefoil, grass alisma
Modoc	Hall's sedge, little hulsea, pyrola-leaved buckwheat, Boggs Lake hedge-hyssop, snow fleabane daisy
Shasta-Trinity	Pyrola-leaved buckwheat, Cascade alpine campion, Aleppo avens
Lassen	Barron's buckwheat, Newberry's cinquefoil, snow fleabane daisy, mud sedge, flat-leaved bladderwort, Lewis Rose's ragwort, rayless mountain ragwort, water bulrush, dwarf resin birch, wooly-fruited sedge, northern spleenwort, English sundew, long-leaved starwort, wooly stenotus, nodding vanilla-grass, squarestem phlox, Janish's beardtongue, little ricegrass
Plumas	Caribou coffeeberry, Mildred's clarkia, Clifton's eremogone, wooly-fruited sedge, water bulrush, buttercup-leaf suksdorfia, yellow willowherb, northern coralroot, Norris' beard moss, hairy marsh hedge-nettle
Tahoe	White-stemmed pondweed, slender-leaved pondweed, English sundew, alder buckthorn
Eldorado	Alpine dusty maidens
Stanislaus	Jack's wild buckwheat, subalpine cryptantha, alpine dusty maidens, cut-leaf checkerbloom, mountain bent grass
Inyo	Field ivesia, Mono Lake lupine, Inyo phacelia, smooth saltbush, slender-leaved pondweed
Sierra	Flat-leaved bladderwort, mud sedge, prairie wedge grass
Sequoia	Field ivesia, copper-flowered bird's-foot trefoil, pygmy pussypaws, Needles' buckwheat, prairie wedge grass, Kern Plateau milk-vetch, delicate bluecup, Greenhorn fritillary, Piute cypress, Mineral King draba, Norris' beard moss, flat-leaved bladderwort

Source: TRA Environmental Sciences, Inc. 2010

Measure BIO-4 is limited to CRPR 1B and CRPR 2 species. The potential impacts to CRPR 3 and CRPR 4 plants are less than significant and are not included in Measure BIO-4. The likelihood of the Project resulting in a substantial adverse impact on CRPR 3 and CRPR 4 species, either directly or through habitat modifications, or changing the diversity of species or number of species, to a point where their populations would be reduced or pushed towards extinction is considered extremely low.

5.3.2.3 Riparian, Wetland, and Other Sensitive Aquatic Communities

OSV Program activities could result in both direct and indirect impacts to aquatic communities. Physical disturbance caused by equipment operating near or in wetlands, streams, rivers, or lakes could directly damage riparian vegetation and stream banks and impact aquatic wildlife. These would be considered significant impacts, and such impacts could occur even with snow and ice cover.

Groomed trails occur over existing roads or OHV trails, and the water crossings are on constructed bridges or are protected by snowpack. Grooming equipment is operated exclusively on roads and trails with a minimum of 12 to 18 inches of snowpack, and snowmobilers typically avoid running the equipment in exposed aquatic habitat (when it is most vulnerable to impacts) because of possible vehicle damage. Off-trail riding in the Project Area can affect aquatic resources if riding takes place in low-snow conditions or by traveling through streams, wetlands, and riparian areas without using formal crossings. In wetland communities, snowmobile activities can result in frost penetrating more deeply thereby delaying the spring thaw (Stangl 1999). Herbs and shrubs in these areas may exhibit localized population declines, and wetland shrubs are highly susceptible to physical damage (Stangl 1999).

If one snowmobile rider crosses a wetland or riparian area during low-snow conditions, it would not likely result in a substantial adverse impact. If however, this occurs repeatedly in the same area, a substantial adverse impact is likely. Apart from Inyo National Forest, which specifically addresses these concerns in its forest policies, other OSV Program national forests do not regularly monitor these resources for OSV impacts. Although national forests have not indicated damage caused by OSV Program activities to aquatic resources, further monitoring and protective measures required under Mitigation Measure BIO-5 would ensure that aquatic resources are adequately protected. Measure BIO-5 protective measures include restricting access to aquatic communities where substantial impacts are observed through educational materials and signage, or, if necessary through the use of barriers or trail re-routes. The OHMVR Division shall revise the annual OSV monitoring checklist used by the USFS to include monitoring of riparian, wetland, and other sensitive aquatic habitats occurring near the groomed trail system.

Concentrations of pollutants from OSVs in snowmelt runoff and the effects they have on aquatic systems are not well understood (Arnold and Koel 2006). Studies show that OSV-related pollution in snowmelt is negligible and does not adversely affect water quality (see Hydrology, Section 6.0). Based on these studies, the OSV Program impact to water quality by VOCs from exhaust emissions is considered less than significant and therefore indirect impacts to aquatic systems related to snowmelt water quality from OSV use is also considered less than significant.

5.3.2.4 Wildlife Movement Corridors

In addition to the direct physiological stress of snowmobiles, evidence suggests that roads and winter trails can fragment habitat and wildlife populations. Winter trails through surrounding wilderness areas or other core areas create more "edge effect" (the negative influence of the periphery of a habitat on the interior conditions of a habitat) and thereby marginalize the vitality of some species (Baker and Bithmann 2005). The groomed trails occur on paved or dirt roads utilized year round for vehicle travel or summer OHV use; consequently, the edge effect of project trails exists year-round. In addition to the edge effect of groomed winter trails, off-trail riding or cutting trails through forested areas can further increase edge effects and fragmentation of habitat (Biodiversity Conservation Alliance 2002). Habitat fragmentation may result in smaller and more isolated wildlife populations more susceptible to the negative effects of inbreeding depression and random events. The groomed trail system funded by the OSV Program has been in existence for many years. OSV use is dispersed across the Project Area and throughout the 14-week snow season. The continuation of this funding as proposed by the Project would not change the extent of existing effects.

5.3.3 10-Year Program Growth, Year 2020

5.3.3.1 Special-Status Species

Expanded Trailhead Parking. New plowing required to open the Four Trees trailhead at Bucks Lake (Plumas National Forest) would provide a new point of access to the existing groomed trail system at Bucks Lake recreation area. The Four Trees trailhead is an existing trailhead that is presently unplowed and therefore closed in winter. Plowing ten miles of the Oroville Quincy Highway to reach the existing Four Trees trailhead parking lot would not modify special-status species habitat or introduce new impacts to special-status species. Vehicle travel on the road already occurs during non-winter months. Keeping the road open in winter does not introduce new impacts to special-status species.

Development of an expanded parking area at the China Wall trailhead is planned by the Tahoe National Forest. Potential impacts of parking lot construction on special-status species would be subject to environmental review separate from the OSV Program (Project Description 2.7.1). Snow removal conducted on the expanded parking lot pavement under the OSV Program would not modify special-status species habitat or otherwise introduce new impacts to special-status species.

Increased Grooming at Existing Trails. Increasing the operating hours of plowing and grooming equipment at the existing trail sites under the 10-year program growth conditions (Project Description, Section 2.7) would not significantly affect special-status species. As described in Section 5.3.2 above, special-status wildlife and plant species are not affected by existing plowing and grooming operations. Increasing the frequency of these operations would not introduce new impact to special-status species.

New Trail Systems. The OHMVR Division has identified three trail sites for potential future inclusion in the OSV Program; however, no immediate plans have been made to establish OSV Program trail systems at these sites (Project Description, Section 2.7.1). Plowing and trail grooming activities at these three sites would not likely have a substantial adverse impact on special status species. Both activities would occur on an established road or OHV trail network and would not modify habitat. Grooming at new trail sites is unlikely to disturb special-status wildlife given the nature of the grooming operation as described in Section 5.3.5.1 above.

OSV use has the potential to disrupt special-status wildlife and plants dependent upon the species present at the potential new trail site and the proximity of OSV use to these species. OSV use already occurs without groomed trails at Lake Davis (Plumas National Forest) and Bass Lake (Sierra National Forest). OSV use does not presently occur on the ungroomed portion of State Route 4 (Humboldt-Toiyabe National Forest) due to lack of access. Establishing a new groomed trail system at Lake Davis, State Route 4, and Bass Lake would likely increase OSV use at these locations and could result in biological impacts. Mitigation measures required for the biological impacts of the existing OSV Program trail systems (Section 5.4) would also reduce the impacts of increased OSV use at new trail system locations to a less than significant level. The increase in OSV activity at these new locations would be required to maintain consistency with LRMP S&Gs and other management prescriptions governing biological resources. Species affected would be similar to those affected by current OSV activities on Plumas, Sierra, and Stanislaus National Forests.

As discussed in the Introduction (Section 1.2), site-specific impacts of developing new trail systems would be subject to environmental review under CEQA as a separate project.

Growth in OSV Recreation. As described in Project Description, Section 2.7.2.1, OSV ownership in California has increased an average of 4% annually from 1997 to 2009. A continuation of this growth rate over the 10-year program period could result in a 48% increase of snowmobiles using the Project Area trails by the year 2020. The increase places more OSVs on project trails and open riding areas in and adjacent to wildlife habitat. Based on the impact analysis presented in Sections 5.3.2 and mitigation measures prescribed in Section 5.4, there are no significant effects of the OSV Program on biological resources identified that cannot be maintained at less than significant levels over the 10-year program period. The growth in OSV use expected over the program period would intensify OSV use in the Project Area but not create new impacts to special-status species that have not already occurred. For example, a trail that currently gets 50 OSVs a day would get 75 OSVs by 2020. The increased OSV use would be dispersed throughout the Project Area and throughout the approximately 14-week snow season. Therefore, the effect of increased OSV use on biological resources over the 10-year program period is not considered significant.

Snowmobile Technology. Advancements in snowmobile technology are expected to continue. Most scientific studies looking at snowmobile effects on wildlife populations were conducted many years ago when snowmobile technology was in its infancy and available speeds were much lower than the high speeds that the current snowmobile models can attain. This advancement in technology could enable an increase of OSV traffic into previously inaccessible backcountry and wildlands possibly affecting individual animals/or populations. However, national forests participating in the OSV Program report that the incidents of trespass into wilderness areas are few (Land Use Plans and Policies, Section 3.3.4). With existing management plans and the addition of Mitigation Measures BIO-1 through BIO-5, technological advances are not expected to result in increased substantial adverse effects upon special-status species over the next 10 years.

5.3.3.2 Riparian, Wetland, and Other Sensitive Aquatic Communities

Increased Plowing and Grooming at Existing Trails. Plowing operations occur on paved road surfaces. Increased plowing frequency on the project access roads would not affect riparian, wetland, or other sensitive aquatic communities. Trail grooming is conducted over an established road network on a minimum snow base of 12 inches. As described in Sections 5.3.3 no riparian, wetland, or aquatic communities are affected by trail grooming. Increased grooming frequency on the existing trail system would not affect riparian, wetland, or other sensitive aquatic communities.

New Trail Systems. As discussed in the Introduction (Section 1.2), site-specific impacts of developing new trail sites would be subject to environmental review under CEQA as a separate project. Any new proposed project would be required to site recreational facilities including new trail systems away from riparian, wetland, and other sensitive aquatic communities by LRMP S&Gs and other management prescriptions governing biological resources. OSV Program participating national forests would continue to use annual monitoring checklists to address biological resource impacts. Mitigation Measure BIO-5 requires corrective actions if substantial adverse impacts are observed during this annual monitoring. Mitigation includes, but is not limited to, restricting access to aquatic communities through educational materials and signage, or, if resource damage consistently shows damage, then through the use of barriers or trail closures or re-routes.

Growth in OSV Recreation. Growth in OSV recreation would increase intensity of use near sensitive aquatic communities and potentially contribute to an increase in impacts to resources. To assure that impacts do not reach significant levels, OSV Program participating national forests would continue to use annual monitoring checklists to address biological resource impacts. Mitigation Measure BIO-5 requires corrective actions if substantial adverse impacts are observed during this annual monitoring. Mitigation includes, but is not limited to, restricting access to aquatic communities through educational materials and signage, or, if resource damage consistently shows damage, then through the use of barriers or trail re-routes.

Advancements in snowmobile technology enable OSV users access to previously undisturbed winter areas. To ensure that impacts do not reach significant levels, OSV Program participating national forests would continue to use annual monitoring checklists to address biological resource impacts. Mitigation Measure BIO-5 requires corrective actions if substantial adverse impacts are observed during this annual monitoring. Mitigation includes, but is not limited to, restricting access to aquatic communities through educational materials and signage, or, if resource damage consistently shows damage, then through the use of barriers or trail closures or re-routes.

5.3.3.3 Wildlife Movement Corridors

Increased Plowing and Grooming at Existing Trails. OSV Program groomed trails occur on paved or dirt roads utilized year round for vehicle travel or summer OHV use; consequently, an increase in plowing and grooming at existing trails would not significantly impact wildlife corridors above existing levels.

New Trail Systems. Any proposed groomed trails would occur on paved or dirt roads utilized for summer vehicle use. These roads already impact wildlife movement year-round. As discussed in the Introduction (Section 1.2), site-specific impacts of developing new trail sites would be subject to environmental review under CEQA as a separate project. If, during review, proposed trails were to significantly impact wildlife movement, alternate trails would be examined at that time.

Growth in OSV Recreation. The projected anticipated increase in riders over the next ten years would not significantly increase the amount of off-trail riding above current levels. The increased

OSV use would be dispersed throughout the Project Area and throughout the 14-week snow season.

Advancements in snowmobile technology enable OSV users access to previously undisturbed winter areas. This activity could impact wildlife movement corridors; however, with the dispersed nature of this activity, advancements in snowmobile technology are not likely to have a substantial adverse impact. As discussed in the Introduction (Section 1.2), site-specific impacts of developing new trail sites would be subject to environmental review under CEQA as a separate project.

5.3.4 Cumulative Impacts

In addition to the OSV Program, ongoing activities occur in national forests throughout the year possibly affecting the same biological resources occurring in the Project Area. A list of specific projects planned or proposed is presented in Appendix G. These activities can all influence wildlife populations by introducing more recreationists into the natural landscape and/or fragmenting wildlife habitat. Presumably, state and national wildlife management agencies would attempt to minimize significant population declines.

Noxious weed growth is a problem throughout California and limits foraging opportunities for big game; this is especially important during the winter as energy expenditures increase in searching for forage. The federal, state, and county agencies have active noxious weed control programs that attempt to prevent further spread of these plants, limiting their effect on most animal species.

Timber harvest, grazing, mining, fires, and fuels reduction projects will continue to occur on federal lands and other lands outside forest boundaries although not all of these activities occur in winter. These actions have variable effects on animal species, sometimes stimulating the growth of their preferred forage and sometimes limiting it. Timber harvest on forest lands is an ongoing activity in places, although more and more of it entails fuels reduction efforts with only small-diameter timber being taken. Grazing can be expected to continue similar to current levels on USFS lands. Mining is more difficult to predict, but would have to undergo NEPA review. Both grazing and mining can significantly affect wildlife species.

Wheeled OHV use occurs on national forest lands year round. The USFS in California is currently working through the Travel Management process, the first step in developing a Travel Management Rule. This effort is the beginning of an ongoing process to provide a sustainable system of roads, trails, and areas for public motor vehicle use on national forest lands, and the end of unmanaged cross-country (off-trail) motor vehicle travel. Unmanaged motor vehicle use has resulted in unplanned roads and trails, erosion, and watershed and habitat degradation. Since 2003, national forests in California have been working to identify existing routes and areas, and to develop changes to motor vehicle use by the public of the existing National Forest Transportation System.

Each national forest within the Project Area is responsible for managing activities occurring within its boundaries in a manner that protects biological resources as prescribed by the LRMP (see Land Use Plans and Policies, Section 3.0). USFS management of the national forests, in compliance with its LRMP policies, mitigates the cumulative effect of activities on biological resources within the national forests. The OSV Program facilitates OSV use, which is a managed use within the national forests. The cumulative effect of the OSV Program, along with other activities occurring within the national forests, is actively managed by implementation of LRMP policies, and therefore the cumulative effect on biological resources is considered less than significant.

5.4 MITIGATION MEASURES

The following mitigation measures would reduce significant impacts to biological resources to a less-than-significant level.

IMPACT*: Northern spotted owls and northern goshawks occur within or near the Project Area. USFS actively monitors nesting habits and fledgling success. Management actions are currently in place that reduce the potential effects of OSV recreation on northern goshawks and northern spotted owls to a less than significant level. The USFS employs adaptive management. Thus, based upon the results of the Regional Northern Goshawk Focused Study and the Northern Spotted Owl Focused Study, biologists may revise the USFS Management Actions.*

Measure BIO-1: USFS shall incorporate the results of the northern goshawk and northern spotted owl studies into management actions and report these actions to the OHMVR Division for incorporation into the OSV Program as soon as revised USFS management actions are formulated.

Implementation:	By OHMVR Division and USFS
Effectiveness:	Implementation of updated management actions would ensure the effects of OSV operations and recreation on northern goshawk and northern spotted owl remain less than significant.
Feasibility:	Feasible
Monitoring:	USFS shall maintain a log of monitoring efforts and any management actions taken to protect northern goshawk and northern spotted owl. This log shall be submitted to OHMVR Division for review each summer prior to contract approval for OSV Program operations for the following winter season.

IMPACT*: California wolverine is not known to be present near OSV sites. If present, disturbance caused by OSV activities may adversely affect California wolverine natal denning behaviors.*

Measure BIO-2: USFS shall continue to work with the Pacific Southwest Research Station and other partners to monitor for presence of California wolverine. If there are verified wolverine sightings, USFS shall conduct an analysis to determine if OSV use within 5 miles of the detection have a potential to affect wolverine and, if necessary, a LOP from January 1 to June 30 will be implemented to avoid adverse impacts to potential breeding.

Implementation:	By OHMVR Division and USFS
Effectiveness:	Implementation would prevent significant impacts to California wolverine from OSV operations.
Feasibility:	Feasible; required by SNFPA S&G #32.
Monitoring:	USFS shall maintain a log of monitoring efforts and any management actions taken to protect California wolverine from OSV use impacts. This log shall be

submitted to OHMVR Division for review each summer prior to contract approval for OSV Program operations for the following winter season.

***IMPACT**: Disturbance caused by OSV activities may adversely affect Sierra Nevada red fox breeding behaviors, home range use, and/or establish trailhead scavenging and begging behaviors.*

Measure BIO-3: Educational materials shall be provided on red fox and the importance of minimizing direct contact with red foxes at each trailhead. USFS shall provide the results of Sierra Nevada red fox inventory and monitoring currently being performed by wildlife biologists from the Forest Service, CDFG, and the University of California, Davis, to the OHMVR Division.

USFS shall work with CDFG, the University of California, Davis, OHMVR, and other partners to continue inventory and monitoring in the Sierra Nevada, including the Project Area where the red fox is most likely to occur (e.g., Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Sierra, Inyo, and Sequoia National Forests). For those portions of the Project Area where presence is confirmed, USFS shall conduct an analysis to determine if OSV use within 5 miles of the detection have a potential to affect Sierra Nevada red fox and, if necessary, a LOP from January 1 to June 30 will be implemented to avoid adverse impacts to potential breeding. The USFS will evaluate activities for a 2-year period for detections not associated with a den site. In addition, if monitoring or other scientific information shows disturbance of Sierra Nevada red fox behaviors within the Project Area, the USFS shall implement suitable management actions to reduce any adverse impacts to a less than significant level. These management actions may include signage, barriers, LOPs, limits on night riding, trail closures, or reroutes of selected portions of OSV trails.

Implementation: By OHMVR Division and USFS

Effectiveness: Implementation of inventory and management actions would prevent significant impacts to Sierra Nevada red fox populations from OSV operations.

Feasibility: Feasible; required by SNFPA S&G #32.

Monitoring: USFS shall provide an inventory report and maintain a log of monitoring efforts and any management actions taken to protect Sierra Nevada red fox. This log shall be submitted to OHMVR Division for review each summer prior to contract approval for OSV Program operations for the following winter season.

***IMPACT**: OSV off-trail riding in low snow conditions could adversely impact individuals and/or populations of CRPR-listed 1B and 2 plant species and FSS plant species.*

Measure BIO-4: The USFS will do one of the following:

(1) Only permit OSV use on the groomed trail system and adjacent concentrated-use riding areas when there is sufficient snow cover (minimum snow depth of 12 inches) to protect soil and vegetation;

(2) Inventory the groomed trail system and adjacent concentrated-use riding areas for all CRPR 1B, CRPR 2, and FSS plant species not already monitored by USFS (Table 5-6) for OSV impacts. Surveys shall focus on locations that are chronically exposed to OSV use and where

plants listed in Table 5-6 have a potential for occurrence and exposure to OSV impacts. The USFS shall conduct public outreach with educational materials until resource surveys are complete. Educational materials shall include information that discourages OSV travel over bare ground, exposed vegetation, and snow less than 12 inches deep, including a description of the special-status plant species potentially affected and the adverse effects on those species. The species previously assessed and not included in this Mitigation Measure include Kern Plateau milk-vetch, Hall's daisy, Kern River daisy, and Kern Plateau horkelia, Mono milk-vetch, Mono Lake lupine, slender Orcutt grass, Barron's buckwheat, and Columbia yellow cress. Follow-up monitoring shall be conducted for those species where presence is confirmed to ensure any protective measures needed to address OSV impacts are identified, implemented, and effective. Protective measures that shall be implemented when needed to avoid damage to special-status plants from OSVs include trail reroutes, barriers, seasonal closures, signage, and/or public education; or

(3) Annually monitor the groomed trail system and adjacent concentrated-use riding areas where plants listed in Table 5-6 have a potential for occurrence. Monitoring shall focus on locations that are chronically exposed to OSV use and where plants listed in Table 5-6 have a potential for occurrence and exposure to OSV impacts. If this monitoring reveals impacts, USFS shall implement protective measures (e.g., temporary fencing, barriers, seasonal closures, signage, trail re-routes, public education, etc.) to restrict access and prevent further damage to these plants and engage in public education. Follow-up monitoring shall be conducted to ensure that protective measures are implemented and effective.

Implementation: By OHMVR Division and USFS
Effectiveness: Completion of inventories and implementation of protective measures would minimize significant impacts on special-status plant species from OSV operations.
Feasibility: Feasible
Monitoring: USFS shall maintain a log of protective measures taken. This log shall be submitted to OHMVR Division for review each summer prior to contract approval for OSV Program operations for the following winter season.

IMPACT*: Chronic disturbance caused by OSVs riding during low-snow conditions over wetlands, riparian areas, streams, and lake ice can adversely affect aquatic communities.*

Measure BIO-5: USFS shall annually monitor aquatic resources in the Project Area near the groomed trail system for damage by OSV use during low-snow conditions. If these assessments reveal impacts, USFS shall implement protective measures (e.g., fencing, signage, trail reroutes, etc.) to restrict access and prevent further resource damage and engage in public education.

Implementation: By OHMVR Division and USFS
Effectiveness: Would prevent significant impacts to aquatic communities from OSV operations.
Feasibility: Feasible; requires increased resource monitoring efforts by USFS.
Monitoring: OHMVR Division shall modify the OSV Program Checklist used by national forests (Appendix C) to include monitoring for damage to aquatic resources. USFS shall maintain a monitoring log along with results, any protective measures taken, and success rate. This log shall be submitted to the OHMVR

Division for review each summer prior to contract approval for OSV Program operations for the following winter season.

6.0 HYDROLOGY AND WATER QUALITY

This chapter describes the hydrologic resources in the Project Area and the potential impacts of project equipment operations and OSV use on water quality.

6.1 REGULATORY SETTING

6.1.1 Federal Clean Water Act

The federal Clean Water Act (CWA) establishes as federal policy the control of point and nonpoint source pollution and assigns to the states the primary responsibility for control of water pollution. The objective of the CWA is to “restore and maintain the chemical, physical, and biological integrity of the Nation’s waters.” Compliance with the CWA by national forests in California is achieved under state law. The CWA requires each state to adopt water quality standards by designating beneficial uses of water to be protected and adopting water quality criteria that protect those beneficial uses. In California, the beneficial uses and water quality objectives are the State’s water quality standards.

Sections 208 and 319 of the CWA address nonpoint source pollution and require water quality management plans for nonpoint sources of pollution. The USFS in the Pacific Southwest Region (Region 5) has worked with the California water quality agencies to meet CWA requirements. The greatest emphasis in this coordination has been on the management and control of nonpoint sources of water pollution, with sediment, water temperature, and nutrient levels of most concern. The State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards (RWQCBs) entered into agreements with the USFS to control nonpoint source discharges by implementing BMPs. These BMPs, which are set forth in the USFS Pacific Southwest Region guidance document, Water Quality Management for Forest System Lands in California, Best Management Practices (2000), constitute a portion of the State’s Nonpoint Source Management Plan and comply with the requirements of Sections 208 and 319 of the CWA. The agreements include BMPs related to OHV use, and to road construction and maintenance. The implementation and effectiveness of the BMPs are reviewed annually. In recent years, the USFS has emphasized monitoring in national forests to ensure the implemented projects follow approved control measures (USFS 2000, 2004b).

6.1.1.1 U. S. Forest Service

Through the execution of a formal Management Agency Agreement with the USFS in 1981, the SWRCB designated the USFS as the Water Quality Management Agency for USFS lands in California. The USFS water quality BMPs (USFS 2000) represent a portion of the State of California's Nonpoint Source Management Plan. The USFS BMPs are in conformance with the provisions and requirements of the federal CWA and within the guidelines of the Basin Plans developed for the nine RWQCBs in California. The USFS BMPs address eight categories: 1) timber management, 2) road and building site construction, 3) mining, 4) recreation, 5) vegetation manipulation, 6) fire suppression and fuel management, 7) watershed management, and 8) range management.

These BMPs do not directly apply to project activities associated with the OSV Program, which is primarily snow grooming on USFS land and snow removal on forest roads and at trailhead parking areas. Of these categories, the most relevant BMPs to the OSV Program pertain to recreation and roads and include the following:

BMP 2-25: Snow Removal Controls to Avoid Resource Damage

a. Objective: To minimize the impact of snowmelt runoff on road surfaces and embankments and to consequently reduce the probability of sediment production resulting from snow removal operations.

b. Explanation: This is a preventative measure used to protect resources and indirectly to protect water quality. Forest roads are sometimes used throughout winter for a variety of reasons. For such roads the following measures are employed to meet the objectives of this practice.

1. The contractor will be responsible for snow removal in a manner which will protect roads and adjacent resources.
2. Rocking or other special surfacing and drainage measures will be necessary before the operator is allowed to use the roads.
3. Snow berms will be removed where they result in an accumulation or concentration of snowmelt runoff on the road and erosive fill slopes.
4. Snow berms will be installed where such placement will preclude concentration of snowmelt runoff and serve to rapidly dissipate melt water. If the road surface is damaged during snow removal, the purchaser or contractor will be required to replace lost surface material with similar quality of material and repair structures damaged in snow removal operations as soon as practical unless otherwise agreed to in writing.

c. Implementation: Project location and detailed mitigation will be developed by the IDT during environmental analysis and incorporate into the project plan and/or contracts. Project crew leaders and supervisors will be responsible for implementing force account projects to construction specifications and project criteria.

BMP 4-7: Water Quality Monitoring of OHV Use According to a Developed Plan

a. Objective: To provide a systematic process to determine when and to what extent OHV use will cause or is causing adverse effects on water quality.

b. Explanation: Each Forest's OHV Plan [Travel Management Plan and LRMP] will:

1. Identify areas or routes where OHV use could cause degradation of water quality
2. Establish baseline water quality data for normal conditions as a basis from which to measure change.
3. Identify water quality standards and the amount of change acceptable.
4. Establish monitoring measures and frequency.
5. Identify controls and mitigation appropriate in management of OHVs.
6. Restrict OHVs to designated routes.

c. Implementation: Monitoring results are evaluated against the OHV plan objectives for water quality and the LRMP objectives for the area. These results are documented along with actions necessary to correct identified problems.

> If considerable adverse effects are occurring, or are likely to occur, immediate corrective action will be taken. Corrective actions may include, but are not limited to, reduction in the amount of OHV use, signing, or barriers to redistribute use, partial closure of areas, rotation of use on areas, closure to causative vehicle type(s), total closure, and structural solutions such as culverts and bridges.

BMP 2-25 and 4-7 are currently in effect. However, the SWRCB is in the process of drafting new BMPs specifically for OHV use on USFS land, which will be in effect to control non-point source pollution in compliance with the federal CWA. It is expected that the new draft BMPs will be released for public review and comment by the end of November 2010. Once adopted, the USFS will be responsible for implementing the new BMPs to ensure that OHV and OSV activities within the national forests are compliant with the CWA (John Stewart and Amy Granat, pers. comm., September 29, 2010)..

6.1.1.2 California Department of Transportation (Caltrans)

Caltrans removes snow on several OSV Program trailheads under contract to Lassen and Sequoia National Forests and Sierra County (Table 2-6). Trailhead parking areas and access roads are nonpoint sources of pollutants managed through Basin Plans and are subject to state water quality requirements of the CWA.

Motorist safety frequently necessitates the use of deicers and abrasives to assist in providing a more negotiable travel way and prevent major slowing of traffic flows within the snow removal areas. The primary anti-icer/deicer currently used is salt and the primary abrasive is sand. Caltrans considers alternative products in an effort to reduce the use of salt and abrasives while still providing a comparable level of safety and service.

Caltrans implements BMPs to minimize water quality effects of its snow removal operations on state-highways. For example, District 3 implements the following management practices as specified in its Caltrans Snow Removal Operations Plan (2009):

> Phase VI, Post Storm Clean-up and Deactivation
>
> 2. Abrasives used during the storm should be retrieved and/or cleaned up in accordance with Best Management Practices (BMP) for Storm Water Guidelines. Maintenance areas in the Tahoe Basin need to perform this activity as quickly as conditions allow after a storm.
>
> 3. The snow storage areas along the shoulders and medians of routes should be reestablished if necessary.

Additionally the Caltrans Snow Removal Operations Plan instructs that the use of deicers and abrasives should always be used prudently and judicially and not distributed unnecessarily. In an effort to control abrasive run off due to storm water flow, straw bales and storm wattles should be placed around abrasive stock piles locations per BMP storm water requirements in an effort to control abrasive run off due to storm water flow.

6.1.1.3 County Public Works

The OSV Program funds snow removal operations by several counties or their contractors (Table 2-6) on county roads. Each county road department manages its own snow removal operations in accordance. For example, Plumas County road maintenance crews clear culvert openings during the thaw period to facilitate snow melt drainage into the designated areas. Culvert outlets are positioned to minimize erosion and sedimentation. Sierra County has informal snow management practices developed over many years that is handed down from operator to operator without formal adoption of BMPs.

6.1.2 Sierra Nevada Forest Plan Amendment

The 2001 Sierra Nevada Framework established for the first time a comprehensive aquatic and riparian conservation strategy for all of the national forest lands in the Sierra Nevada. The Sierra Nevada Framework applies to all of the Project Area national forests except for Klamath and Shasta-Trinity National Forests. Key components of this strategy include riparian buffer zones, critical refuges for threatened and endangered aquatic species, special management for large meadows, and a watershed analysis process. The Framework includes S&Gs in national forests for construction and relocation of roads and trails and for management of riparian conservation areas. These S&Gs require the USFS to avoid road construction, reconstruction, and relocation in meadows and wetlands; maintain and restore the hydrologic connectivity of streams, meadows, and wetlands by identifying roads and trails that intercept, divert, or disrupt flows paths and implementing corrective actions; and determine if stream characteristics are within the range of natural variability prior to taking actions that could adversely affect streams.

The Framework's S&Gs for riparian conservation areas are intended to minimize the risk of activity-related sediment entering aquatic systems. The Framework established riparian conservation area widths for all Sierra Nevada forests: 300 feet on each side of perennial streams; 150 feet on each side of intermittent and ephemeral streams; and 300 feet from lakes, meadows, bogs, fens, wetlands, vernal pools, and springs (Forest Issues Group 2009).

6.1.3 National Forest Land and Resource Management Plans

The LRMPs of each of the national forests include management direction related to water resources. The LRMP forest-wide S&Gs and management prescriptions are discussed in Land Use Plans and Policies (Section 3.0). These policies are listed in Appendix D, Tables 1 and 2.

6.1.4 The Porter-Cologne Water Quality Act

Water quality in California is governed by the Porter-Cologne Water Quality Control Act (Porter-Cologne; Calif. Water Code sections 13000 et seq.), which establishes the regulatory authority of the state over activities and factors that may affect the quality of the waters of the state. This law assigns overall responsibility for water rights and water quality protection to the SWRCB and directs the nine statewide RWQCBs to develop and enforce water quality standards within their boundaries.

The SWRCB sets statewide policy for the implementation of state and federal laws and regulations. Each RWQCB is charged with developing, adopting, and implementing a Water Quality Control Plan (Basin Plan) for each region. Basin Plans are mandated by both the federal CWA and the Porter-Cologne Water Quality Act. Basin Plans are adopted for each of the nine water quality regions. The Basin Plans, which apply to waters on the national forests, contain the water quality standards that are the basis for the RWQCBs' regulatory programs. The water quality standards consist of designated beneficial uses (e.g., wildlife habitat, recreation, groundwater recharge, etc.) for individual surface water bodies and groundwater, as well as the narrative and numerical water quality objectives which must be maintained or attained to protect those beneficial uses. The Basin Plans also contain waste discharge prohibitions and other implementation measures to achieve water quality objectives. Water quality control measures include Total Maximum Daily Loads required by the federal CWA.

Under Porter-Cologne, RWQCBs regulate the discharge of waste to "waters of the state." All parties proposing to discharge waste that could affect waters of the state must file a report of waste discharge (RWD) with the appropriate RWQCB. The RWQCB will then respond to the report of waste discharge by issuing waste discharge requirements (WDRs) in a public hearing or by waiving WDRs (with or without conditions) for that proposed discharge. Porter-Cologne allows a water board to waive RWD requirements and subsequent issuance of WDRs for specific types of discharges, when those discharges comply with any applicable water quality control plan and are in the public interest. When final, the new BMPs discussed above that specifically address OHV use are anticipated to support a waiver from RWD requirements for a broad range of activities on USFS lands, including recreational activities likely to have water quality impacts.

6.2 ENVIRONMENTAL SETTING

6.2.1 Regional Hydrology

6.2.1.1 Southern Cascade Range

The Cascade Mountain Range (Cascades) extends from British Columbia south through Washington and Oregon to northern California, mostly consisting of a series of volcanoes. In the southern portion of the Cascades occurring in California, the volcanic peaks include Mount Shasta, Medicine Lake Volcano, and Lassen Peak. Mount Shasta dominates with a peak elevation over 14,000 feet, while Lassen Peak at the southern limit of the range reaches an elevation of 10,000 feet. The western slope of the southern Cascades north of Lake Shasta drains toward the Klamath and Shasta Rivers to Lake Shasta. South of Lake Shasta, the western slope of the Cascades drains toward the Sacramento River and through the Central Valley. The eastern slope of the Cascades drains toward numerous lakes, ponds, and reservoirs on the Modoc Plateau – a volcanic tableland (elevated platform of volcanic deposits) with elevations ranging from 3,000 to 9,900 feet. The Pit River drains the northern half of the Modoc Plateau in a southwesterly direction from the Warner Mountains in the northeast corner of the state through the Cascades to Lake Shasta.

The Cascades receive 20 to 80 inches of precipitation annually with most of it occurring as snow. Summers see very little precipitation, and ambient air temperatures frequently exceed 100 degrees Fahrenheit. Water flows are particularly vulnerable to drought conditions, premature snow melting, heat waves, or high ambient temperatures (USDI 2004).

6.2.1.2 Sierra Nevada

The Sierra Nevada extends 400 miles along eastern California, bounded on the west by the Central Valley (comprised of the Sacramento Valley and San Joaquin Valley) and on the east by the Great Basin. The northern Sierra Nevada is characterized by rolling uplands, mostly less than 9,000 feet in elevation, while the high peaks of the central and southern Sierra reach elevations of over 14,000 feet. The high Sierra contains more than 4,000 lakes and a myriad of springs, seeps, and wetlands occur throughout the range. On the west side of the Sierra Nevada, waters from the northern half of the range drain to the Sacramento River and flow south through the Sacramento Valley, and waters from the southern half of the range flow to the San Joaquin River through the San Joaquin Valley. The Sacramento and San Joaquin Rivers both flow to the San Francisco Bay and the Pacific Ocean. The major watersheds along the west slope of the Sierra Nevada are defined by the Feather, Yuba, American, Cosumnes, Mokelumne, Stanislaus, Tuolumne, Merced, San Joaquin, Kings, Kaweah, and Kern Rivers. North of Yosemite National Park, the eastern slope of the Sierra Nevada drains toward the Great Basin in Nevada. The Truckee, Carson, and Walker Rivers are the major rivers flowing east from the Sierra Nevada toward the Great Basin. Waters on the eastside of the Sierra Nevada crest from Yosemite southward flow in a southern direction to the Mono Lake Basin and through the Owens Valley in the Owens River toward the Mojave Desert.

The Sierra Nevada climate is dominated by a pattern of cool wet winters followed by a long dry period in spring, summer, and fall. Approximately 50 percent of the annual precipitation occurs in winter, 33 percent in fall, 15 percent in spring, and only two percent in summer. The Pacific Ocean is the primary influence on storm tracks. Winter storms are moisture laden and release heavy precipitation on the west slope. Snow covers the landscape down to approximately 6,000 feet. Winter storms are generally more frequent north of Lake Tahoe, whereas the southern Sierra receives summer moisture as a result of monsoonal activity originating in the interior Southwest and Gulf regions. Precipitation increases with elevation. The Sierra Nevada summit wrings water from winter storms and summer convection systems, leaving the eastern slopes much drier. Soils generally have high infiltration rates, and precipitation is usually absorbed into the soil (USFS 2004b).

6.2.2 Project Area

6.2.2.1 Hydrology

OSV Program trail sites in the Klamath, Modoc, Shasta-Trinity, and Lassen National Forests are located in the southern Cascades with the majority occurring on the east side of the crest (Table 6-1). OSV Program project sites in the Plumas, Tahoe, Eldorado, Stanislaus Inyo, Sierra, and Sequoia National Forests are located in the Sierra Nevada. Of the 25 OSV Program trailheads in the Sierra Nevada, six are located on the east side of the Sierra Nevada crest (Table 6-1). These include Gold Lake on Plumas National Forest, Little Truckee Summit and Bassetts on the Tahoe National Forest, Mammoth Lakes on the Inyo National Forest and the two Kern Plateau trailheads on the Sequoia National Forest. Portions of the trails accessed from Quaking Aspen and Sugarloaf trailheads run along the Sierra Nevada crest known as the Western Divide.

There are many streams, lakes and reservoirs within the Project Area. Many water bodies are directly accessed or crossed by the Project trails and many more can be accessed by off-trail cross-country riding. Major water bodies identified by each individual national forest as accessible by OSV are presented in Table 6-1. Inyo National Forest notes that many of its water bodies can only be accessed during limited periods due to inconsistent snowpack. Tahoe National Forest notes that many high altitude lakes such as those near or above 7,000 feet in elevation are frozen over in the winter.

The hydrology of the Project Area is dynamic and evolving. There can be significant annual variations in water availability and quality, seasonal flow rates, and water temperatures. Precipitation and snow accumulation also change over time as a result of climate change. Modern human activities have altered the natural dynamics of water through the construction of dams and diversions, watershed practices that alter water yields, temperature, and sedimentation, and the introduction of pollutants and exotic biota. Forestry practices and fire suppression have also influenced erosion and flooding. Limited localized winter and early spring flooding in portions of the Project Area can result from rapid and concentrated snowmelt, rain-on-snow events, severe summer thunderstorms, or the displacement of lake water by snow avalanches or landslides.

6.2.2.2 Water Quality

Located in high elevations of the Cascades and Sierra Nevada, the project activities occur on snowpacks forming the headwaters of many watersheds. These elevations generally produce surface water of excellent quality. Contaminant levels in most waters meet State standards and the fishable and swimmable objectives of the federal CWA. Most pollutants come from nonpoint sources, such as erosion from roads and parking areas. Sediment at levels above natural rates of erosion is the most common nonpoint source pollutant in forested ecosystems (USFS 2001).

The Project Area separates into three water quality management regions regulated by the RWQCBs: North Coast Region (Region 1), Central Valley Region (Region 5), and Lahontan Region (Region 6).

North Coast Region. The North Coast Region encompasses the Klamath River and North Coastal Basins covering the high broad valleys in the north central part of the state, as well as the Klamath and Coast Ranges. The three trail systems on the Klamath and Modoc National Forests are located within the North Coast Region. The water quality within the North Coast region generally meets or exceeds the water quality objectives set forth in the Basin Plan, although there are some localized problems (North Coast RWQCB 2007).

Table 6-1. Major Water Bodies Accessible by OSV in the Project Area

National Forest/ Trail System	Major Water Body
Cascade Mountain Range – East Side	
Klamath/Deer Mountain and Four Corners	Orr Lake
Modoc/Doorknob	Medicine Lake
Shasta-Trinity/Pilgrim Creek	Pumice Stone Well and Tamarack Lake
Lassen/Ashpan	North Battle Creek Reservoir
Lassen/Bogard	Crater Lake
Lassen/Fredonyer	McCoy Flat Reservoir and Hog Flat Reservoir. Both devoid of water in 2007, 2008, and 2009.
Lassen/Swain Mountain	Silver Lake, Caribou Lake, Echo Lake, Lake Almanor
Cascade Mountain Range – West Side	
Lassen/Morgan Summit	No lakes occur near trail system
Lassen/Jonesville	Lake Almanor
Sierra Nevada – West Side	
Plumas/Bucks Lake	Bucks Lake
Plumas/La Porte	Little Grass Valley Reservoir
Tahoe/China Wall	French Meadows
Eldorado/Silver Bear	Bear River Reservoir

Table 6-1. Major Water Bodies Accessible by OSV in the Project Area

National Forest/ Trail System	Major Water Body
Stanislaus/Lake Alpine and Spicer Reservoir	Spicer Reservoir, Utica Reservoir, and Lake Alpine
Stanislaus/Highway 108	Donnell Lake and Relief Reservoir
Sierra/Huntington Lake/Kaiser Pass and Tamarack Ridge	Deer Lake, Edison Lake, Florence Lake, Huntington Lake, Strawberry Lake, Red Lake, and West Lake
Sequoia/Big Meadow/ Quail Flat	Located in Sequoia National Monument. OSV use is limited to roads with bridges or culverts at stream crossings. No water bodies are accessible.
Sequoia/Quaking Aspen/ Sugarloaf	Located in Sequoia National Monument. OSV use is limited to roads with bridges or culverts at stream crossings. Portion of trails east of Sugarloaf is outside of National Monument and has access to small creeks. No lakes occur within Project Area.
Sierra Nevada – East Side	
Plumas/Gold Lake	Gold Lake and numerous small lakes in Lakes Basin
Tahoe/Bassetts	Salmon Lake and Sardine Lake
Tahoe/Little Truckee Summit	Independence Lake, Weber Lake, Jackson Meadows Reservoir, Meadow Lake, White Rock Lake, Lake of the Woods, Little Truckee River, Stampede Reservoir, Prosser Reservoir, and Boca Reservoir.
Inyo/Mammoth Lakes	Ellery, Grant, June, Laurel, Mammoth, Silver, and Tioga Lakes Convict, Deadman, Glass, Laurel, Mammoth, McGee, Reverse, Sherwin, and Upper Owens Creeks
Sequoia/Kern Plateau	No lakes occur within Project Area.

Source: USFS 2009

Central Valley Region. The Central Valley Region extends from the Oregon border at the Warner Mountains to the southern end of the San Joaquin Valley, and from the crest of the Sierra Nevada west to the Coast Range and Klamath Range. It includes the watershed of the Pit River which drains the Modoc Plateau on the east side of the Cascades to Shasta Lake and the Sacramento River. The 19 project sites on the west side of the Sierra Nevada crest (Table 6-1) plus the one project site on the Shasta-Trinity National Forest in the Cascades are all located within the Central Valley Region. The Central Valley Region is divided into three basins: the Sacramento River Basin, the San Joaquin River Basin, and the Tulare Lake Basin. Major groundwater basins underlie the valley floors. Water quality in the mountain portions of the Sacramento and San Joaquin River Basins is affected by sedimentation and herbicide use from timber harvest activities. Water quality in the mountain streams of the Tulare Basin is generally excellent (California RWQCB Central Valley Region 2004 and 2007).

Lahontan Region. The Lahontan Region includes all areas draining east from the Cascades and Sierra Nevada toward the Great Basin as well as all land on the east side of the Sierra Nevada crest from the Mono Lake Basin to the Mojave Desert. The Lahontan Region contains 15 major watersheds. This region is mostly in the Sierra Nevada rain shadow and receives little precipitation. There are 13 project sites in the Lahontan Region: seven in the Cascades (Lassen National Forest) and six in the east side of the Sierra Nevada (Plumas, Tahoe, Inyo, and Sequoia National Forests) as shown in Table 6-1. The quality of most higher elevation waters derived from snowmelt is generally very good or excellent, with some localized problems. Water quality problems in the Lahontan Region are largely related to erosion from construction, timber harvesting, and livestock grazing (California RWQCB Lahontan Region 2005).

6.3 PROJECT IMPACTS

6.3.1 Thresholds of Significance

According to Appendix G of the CEQA Guidelines, a project would normally be considered to have a significant adverse impact on the environment if it would:

- Substantially alter the existing drainage pattern of the site or area, including the alteration of the course of a stream or river in a manner that would modify the capacity or hydraulics of the stream or result in substantial erosion or siltation, on- or off-site;
- Substantially alter the existing drainage pattern of the site or area, including the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site;
- Create or contribute runoff water that would exceed the capacity of existing or planned storm water drainage systems or provide substantial additional sources of polluted runoff;
- Change the amount of surface water in any water body;
- Violate any water quality standards or waste discharge requirements;
- Affect surface water quality (contaminants including silt, urban runoff, nutrient enrichment, pesticides, etc.);
- Affect a private or public water supply that results in any change in water quality or available water quantity;
- Otherwise substantially degrade water quality;
- Place within a 100-year flood plain hazard area structures that would impede or redirect flood flows;
- Substantially deplete ground water supplies or interfere substantially with ground water recharge such that there would be a net deficit in aquifer volume or a lowering of the local ground water table level (e.g., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted);
- Affect the quality of ground water supply, or alter the direction or rate of flow to ground waters; or
- Result in substantial soil erosion or loss of topsoil.

The Project would not involve the construction of any structures which could impede or redirect flood flows, nor any ground modifications which could change drainage patterns, impervious surfaces, soil permeability, or other hydrological characteristics such as surface water volumes. The Project would not expose people or property to a risk of flooding nor increase the risk of flooding for existing development in floodplains in the Project Area. The Project would not place housing or other structures within a flood hazard area. Therefore these issues are not further analyzed in this chapter.

The Project would not involve a change in water use, affect a private or public water supply, or affect the quantity or quality of groundwater recharge, aquifer volume or cause a lowering of the local groundwater table level. The Project would not involve an increase in impervious surfaces. Therefore, these issues are not further analyzed in this chapter.

The Project does not involve discharges of storm water or wastewater. Therefore these issues are not further analyzed in this chapter.

This chapter focuses on the project's potential to cause soil compaction or erosion, or to affect water quality.

6.3.2 Project Baseline, Year 2010

6.3.2.1 Soil Compaction and Erosion

Snow Removal and Passenger Vehicle Travel. Snow removal and subsequent vehicle travel occur on paved surfaces and do not cause soil disturbance, alter existing drainage patterns, or affect soil permeability.

Snow removed from the trailheads and access roads is stored along road shoulders and trailheads in areas established by Caltrans (on state highways), county road departments (on county roads), or national forests (USFS lands). Snow removal on the access roads and trailhead parking areas has been occurring for decades. These agencies are responsible for ensuring that snowmelt from snow storage areas does not result in erosion or impair quality of surface waters, including by employing the BMP measures identified above in Section 6.1.1. The thaw rate in snow storage areas is typically slow, and snow is placed where the runoff percolates into the soil. High runoff rates are uncommon from snow storage areas. As a result erosion or siltation from snow storage runoff is minimal. With implementation of the BMPs, snow removal would not cause significant impacts from erosion. See Section 6.3.2.2 below for further discussion of potential water quality impacts from snow removal.

Trail Grooming. All trail grooming occurs on either paved roads or compacted dirt and gravel surfaced roads open to motorized travel and OHV use in non-winter months. Grooming equipment operates only when there is a minimum of 12 inches of snow cover (and in certain national forests, a minimum of 18 or 24 inches). Therefore trail grooming does not disturb the underlying soils and does not result in soil compaction or erosion impacts.

OSV Use. OSV use on groomed trails in low snow conditions creates minimal soil impacts. The groomed trails occur on paved, dirt, or gravel roads which are actively maintained in non-winter months by the national forest.

Erosion occurs as a direct result of complex interactions between site topography, soils, vegetation, and geology and external factors such as logging, grazing, wildfires, and other activities that disturb the forest floor and compact soil. Some researchers have found that snowmobiles can contribute to erosion of trails and steep slopes. As noted in Olliff et al. (1999), if steep slopes are intensively used, snow may be removed and the ground surface exposed to extreme weather conditions and increased erosion by continued snowmobile traffic. Similar results could occur when snowmobiles use exposed southern exposures. Because compacted snow generally takes longer to melt, trails may be wet and soft when the surrounding areas are dry, creating trails that are susceptible to damage by other users during the spring.

OSV use in off-trail open riding areas where there is minimal snow cover or bare patches of ground could potentially result in destruction of vegetation, soil compaction, and erosion in areas of repeated and concentrated use. Off-trail OSV use is generally dispersed and does not result in high concentration of OSV use on bare soil. Also, travel over bare soil can damage machines and is therefore typically avoided by OSV users. As a result, soil compaction and erosion is not a commonly observed condition during USFS trail monitoring (USFS 2009c). A snowmobile and rider exert considerably less pressure on the bare ground than other recreational activities such as hiking as shown in Table 6-2. The pressure of the snowmobile's weight on soil is further reduced by an intervening blanket of snow, making compaction impacts less than significant.

Routes are monitored by USFS after winter snows melt and repairs are made as needed to stabilize the trail and any stream crossings, limit the amount of stream sedimentation, and prevent flow diversions or alterations of the stream channel. Drainage repairs include water bars, adding barriers to prevent entry into streams, and hardening the road surface to prevent erosion. These activities are a routine part of USFS trail maintenance activities. Since the Project does not alter landform and has minimal disturbance of bare soil, the erosion impacts of the project are less than significant.

Table 6-2. Pressure Exerted on Earth Surface from Recreational Activity

Object	Pounds of Pressure per square inch
Four-Wheel Drive Vehicle	30
Horse	8
Man	5
All-Terrain Vehicle	1.5
Snowmobile	0.5

Note:
All vehicle weights considered include 210 pounds estimated weight of one person and gear.

Source: American Council of Snowmobile Associations 2010

6.3.2.2 Water Quality

Snow Removal and Passenger Vehicle Travel. The snow removal operations on paved access roads and trailhead parking areas would not result in direct impacts on water quality. Sand, or an equally environmentally neutral substance, may be used for traction in plowed areas. De-icers may be applied to access roads in accordance with Caltrans or county practices. Snow melt from snow storage areas could contain a more concentrated level of fuel deposits, oils, sand, and particulates. Snow is removed to designated storage areas where the snow melt can percolate into the soil and sheet flow across parking areas is avoided; direct discharge into surface water is avoided. As a result, the potential for water quality impacts associated with contaminants in the snow from vehicle use is considered less than significant. Snow removal operations are subject to county, state, or federal BMPs as described above in Section 6.1.1, which ensures compliance with federal CWA requirements.

Plowing equipment can deposit fuel oils on the road surfaces along with the vehicles using the roads and parking areas. Roads are a nonpoint source of water pollutants from vehicle use – primarily hydrocarbons. By plowing the roads and parking areas in the winter, the Project extends vehicle use of these areas to year round. The proportion of vehicle traffic and snow plowing which occurs on these roads during the approximately 14-week project period is small in comparison to the year round vehicle travel that occurs. The water quality contaminants associated with vehicle use on roads during the project period is considered less than significant.

Trail Grooming and OSV Use. In addition to exhaust emissions, grooming equipment and OSVs can leave behind unburned fuel, lubrication oil, and other compounds on the top layers of snow, and these pollutants can eventually find their way into surface and groundwater. These pollutants can accumulate in snowpack and if present in sufficiently high concentrations, such pollutants could adversely affect surface water quality and aquatic ecosystems by changing pH, hydrogen, ammonium, calcium, sulphate, and nitrate levels, and by contributing harmful levels of VOCs (Arnold and Koel 2006).

Concentrations of pollutants from OSVs in snowmelt runoff and the effects they have on aquatic systems are not well understood (Arnold and Koel 2006). However, studies conducted in the Rocky Mountains region provide some indication of the potential effects of pollution deposition from OSV use. The U.S. Geological Survey monitored the snowpack throughout the northern Rocky Mountains over a period of several years to measure regional water quality trends as well as the effect of OSV use. The monitoring showed a relationship between OSV use and pollutant deposition in the snowpack, but not more than negligible to minor quantities of OSV-related pollution in snowmelt. Detectable vehicle-related pollution in snowmelt was found to be in the range of background or near-background levels (Ingersoll et al. 2005 as cited in NPS 2007).

A study in Yellowstone National Park analyzed snowmelt from four test locations adjacent to roadways and parking lots heavily used by OSVs between Yellowstone's West Entrance at West Yellowstone, Montana, and the Old Faithful visitor area. The purpose of the study was to evaluate whether increased snowmobile use within the Park was creating increased potential for emissions to enter pristine surface waters. Specific objectives were to 1) examine snowmelt runoff for the presence of specific VOCs, 2) determine if concentrations of any VOCs exceed safe drinking water criteria, and 3) predict the potential for impacts by VOCs on the fauna of streams near roads heavily used by snowmobiles in the park. In spring 2003 and 2004, water samples were collected and tested. In situ water quality measurements (temperature, dissolved oxygen, pH, specific conductance, and turbidity) were collected; all were found within acceptable limits. Five VOCs were detected (benzene, ethylbenzene, m- and p-xylene, o-xylene, and toluene). The concentrations were found below EPA criteria and guidelines for the VOCs analyzed and were below levels that would adversely impact aquatic ecosystems (Arnold and Koel 2006).

The number of snowmobiles that entered Yellowstone in 2003 and 2004 was 47,799 and 22,423 respectively (Arnold and Koel 2006). The estimated seasonal use of OSV Program trails in half of the national forests is less than 11,000 OSVs (see Project Description, Table 2-8). The other half has estimated seasonal OSV use levels between 17,000 and 41,000. These visitations are spread across multiple trailheads and trail systems and do not all occur in the same location. Given that OSV seasonal use levels at any project trailhead or trail system is considerably less than OSV use occurring at Yellowstone National Park and that the Yellowstone OSV use levels studied had not resulted in impaired water quality, it can be concluded that the OSV use in the Project Area from the OSV Program does not adversely affect water quality of snowmelt. The impact is therefore considered less than significant.

6.3.3 10-Year Program Growth, Year 2020

6.3.3.1 Soil Compaction and Erosion

Expanded Trailhead Parking. New snow removal operations on the Oroville Quincy Highway and at the Four Trees and China Wall trailhead parking areas and the subsequent increase in passenger vehicle travel to the Project Area using the newly plowed access or parking areas would all occur on paved roads and would not result in soil compaction or erosion. The snow that is removed from these areas would be stored along the trailheads in areas to be established by the county road departments, possibly in consultation with the national forests. As discussed in Section 6.3.2.1, snowmelt from snow storage areas does not result in significant erosion.

Increased Grooming at Existing Trails. Growth in OSV Program operations could result in an additional 500 hours of trail grooming throughout the Project Area at existing trail locations (Project Description, Section 2.7.1). The increase in equipment hours would not affect soils since the grooming equipment is operated either on paved roads or compacted dirt roads with a minimum of 12” depth of snow cover. There are no soil compaction or erosion impacts associated with this activity. See Section 6.3.2.1 above.

New Trail Systems. Snow removal operations and passenger vehicle travel to the potential new trail sites would occur on paved roads and not result in soil compaction or erosion. Grooming operations at the new trail sites would be established on an existing road network with a minimum of 12” depth of snow cover. Roughly 200 hours of grooming at each potential new trail site would likely occur (Project Description, Section 2.7.1). There would be no direct soil compaction or erosion impacts associated with grooming activity. See Section 6.3.2.1 above. Subsequent OSV use at these new trail sites could result in OSV contacting bare soil in low snow conditions. However, OSV use does not result in significant soil compaction as shown in Table 6-2, and soil erosion is not expected to be significant given that OSV contact with soil is minimal. Therefore, the impact of OSV use at new trail systems on soil compaction and erosion is less than significant.

Growth in OSV Use. Soil compaction and erosion impacts associated with operation of OSV use are minor. Increasing OSV use in the Project Area could increase the potential for snowmobiles to contact bare soil in low snow conditions. However, OSV use does not result in significant soil compaction as shown in Table 6-2, and soil erosion is not expected to be significant given that OSV contact with soil is minimal. Therefore, the impact of the Project on soil compaction and erosion from increased OSV use levels projected for Program Year 2020 is less than significant.

6.3.3.2 Water Quality

Expanded Trailhead Parking. New snow removal on Oroville Quincy Highway, Four Trees trailhead, and the expanded China Wall trailhead parking off Foresthill Road would increase snow removal operations by slightly more than 500 hours per year. The plowing would accommodate an increase in passenger vehicles traveling to Bucks Lake and China Wall groomed trail systems. Increased snow removal and passenger vehicles would increase the exhaust emissions and fuel deposits on paved roads which can affect water quality of surface runoff. The proportion of vehicle traffic and snow plowing which occur on these roads during the 14-week project period is small in comparison to the year-round vehicle travel that occurs on these same roads. The water quality contaminants associated with vehicle use on roads which can be attributed to the OSV Program is considered less than significant.

The snow that is removed from these areas would be stored in areas designated by the county road departments, possibly in consultation with the national forests. De-icers or sand may be applied to the Oroville Quincy Highway or within the Four Trees and China Wall parking areas. As discussed in Section 6.3.2.2, snow melt from snow storage areas could contain a more concentrated level of fuel deposits, oils, sand, and particulates. The snow removed from Oroville Quincy Highway and the trailhead areas would occur in accordance with practices of each county road department. Snow storage areas are located in designated areas where snow melt can seep into the ground and sheet flow across parking areas or direct discharge into surface water is avoided. As a result, the potential for water contaminants in snowmelt from snow storage areas to impair surface water quality is considered less than significant.

Increased Grooming at Existing Trails. Grooming equipment exhaust deposits on the snowpack are not considered significant. Increasing annual equipment hours of operation by 500 hours would increase the exhaust deposit. This increase would occur over 1,761 miles of groomed trail and 26 trail systems. The increase in grooming operations would not raise hydrocarbon emissions in runoff to significant levels.

New Trail Systems. The three potential new trail sites identified in Project Description, Section 2.7.1, would add less than 200 new equipment hours for snow removal to provide plowed access and parking. Plowing on the access roads to Lake Davis and Bass Lake already occurs by county road departments. Plowing on State Route 89 to access a new trailhead on State Route 4 near Monitor Pass, would be new plowing. Vehicle exhaust and nonpoint source water pollutants are not new to these roads. Any increase in nonpoint source pollutants from the snow removal equipment, and passenger vehicle travel associated with the development of new trail systems, at these locations would be minor and less than significant.

The three new trail systems (Lake Davis, State Route 4, and Bass Lake) would combine for 68 miles and are estimated to require 600 new hours of grooming equipment operation. Based on a total parking capacities of 65 vehicles, the three sites combined would support an increase of 5,980 OSV seasonal use days. The largest of the three sites, State Route 4, would support 2,760 OSV seasonal use days. This level of OSV use is far less than the approximate seasonal use levels at Yellowstone of up to 48,000 which were determined to have a less than significant impact on water quality (Section 6.3.2.2 above). Therefore, the water quality impact from these three new trail systems would be less than significant.

Growth in OSV Recreation. OSV exhaust deposits on the snowpack from the OSV Program at 2010 baseline levels are not considered significant (Section 6.3.2.2). Growth in OSV use as projected during the 10-year program period would not raise hydrocarbon emissions in runoff to significant levels. The maximum OSV use projected for 2020 at a single trail system location occurs at Mammoth Lakes (Inyo National Forest). In 2010, seasonal OSV use at Mammoth Lakes is estimated at 17,152 (Table 2-8). Based on a 4% average annual increase over the 10-year program period, OSV seasonal use days at Mammoth Lakes could increase to 25,389. This remains less than the OSV seasonal use levels at Yellowstone which were determined to have a less than significant impact on water quality. Therefore, the impact of the OSV Program on water quality projected for Program Year 2020 is considered less than significant.

6.3.4 Cumulative Impacts

There are many scheduled projects identified in the national forests (Appendix G) which are ground disturbing and could add sediment to surface waters within the forest. The USFS utilizes BMPs in compliance with the CWA to minimize water quality impacts. Non-winter OHV recreation use on designated trails could contribute toward soil erosion and sediment transport to creeks. The USFS is working to create Travel Route Designations to establish a managed network of forest roads and trails suitable for off-road recreation (see Recreation, Section 8.1.4). By restricting vehicle use to designated routes and closure of non-designated routes, the cumulative effect of soil erosion from summertime road use is addressed. National forests monitor road and trail conditions and implement BMP to control erosion (USFS 2000). National forests which receive California funds under the OHV Grants Program also maintain OHV trails in accordance with the state Soil Conservation Standard and Guidelines (CDPR 2008) in addition to compliance with CWA requirements. Based on active management by the national forests to control soil erosion, the cumulative effects of the project on soil erosion and sedimentation of drainages is less than significant.

6.4 MITIGATION MEASURES

No significant impacts related to hydrology and water quality were identified; no mitigation measures are necessary.

7.0 NOISE

This chapter addresses the noise effects of operating plowing and grooming equipment associated with the OSV Program and the indirect effects of snowmobile noise on recreation in the Project Area. Noise impacts on biological resources are addressed in Biology, Section 5.3 and noise impacts on recreational uses are addressed in Recreation, Section 6.3.

7.1 REGULATORY SETTING

Noise emitted by vehicle is regulated by CVC Section 27200.

For heavy equipment such as snowcats used for grooming project trails and snow plow equipment, CVC Section 27204, limits noise to 80 dbA for equipment with a gross vehicle weight rating of 10,000 pounds and manufacture year after 1987.

For snowmobiles manufactured after 1972, CVC Section 27203 sets the noise limit at 82 dBA. The noise level generated by an OSV is further limited through manufacturer restrictions. Snowmobiles produced since February 1, 1975 and certified by the Snowmobile Safety and Certification Committee's independent testing company emit no more than 78 dBA from a distance of 50 feet while traveling at full throttle when tested under the Society of Automotive Engineers (SAE) J192 procedures. Additionally, those produced after June 30, 1976 and certified by the Snowmobiles Safety and Certification Committee's independent testing company emit no more than 73 dBA at 50 feet while traveling at 15 mph when tested under SAE J1161 procedures.

OSV use on county roads and national forest lands are subject to the state standards described above. Individual LRMP for the national forests do not identify S&Gs regulating noise emissions of forest activities.

7.2 ENVIRONMENTAL SETTING

7.2.1 Noise Terminology

Noise is defined as unwanted sound and is widely recognized as a form of environmental degradation. The frequency, duration and intensity of noise contribute to the effect on the listener.

7.2.1.1 The Decibel Scale (dB)

Noise is measured on the logarithmic decibel scale (dB), usually with a frequency sensitivity that matches the human ear, called "A-weighting." Thus, most environmental measurements are reported in dBA, meaning decibels on the A-scale. The logarithmic scale means that a sound level reported as 60 dBA has 10 times the sound energy as a sound with a level of 50 dBA; a sound of 63 dBA is twice as loud as a sound of 60 dBA.

Human hearing matches the logarithmic A-weighted scale, so that an increase of 3 dB is usually perceptible, and in a complex noise environment such as along a street, noise must increase by 5 dB to be considered perceptible. Conversation is in the range from 50 to 65 dBA; with levels rising as the distance between speakers increases or as background noise level rises forcing the speakers to raise their voice in order to be heard. Generally, as environmental noise exceeds 50 dBA, it becomes intrusive and above 65 dBA, noise becomes excessive. Table 7-1 lists typical outdoor noise levels.

Table 7-1. Typical Outdoor Noise Levels

Common noise levels	Noise level (dBA)
Jet flyover at 1,000 feet	105
Gas lawn mower at 3 feet	95
Roadway in commercial area at 50 feet (area of rough pavement)	75-80
Quiet urban daytime	50
Quiet urban nighttime	40
Quiet suburban nighttime	35

Source: Caltrans 1991

7.2.1.2 Sound Levels

The equivalent noise level, Leq, represents the level of a steady noise having the same sound energy as the time-varying noise measured. Leq (h) represents the time-weighted average for a 60-minute (hourly) period. Leq is useful for evaluating shorter time intervals over the course of a day. Recording a series of Leq values allows the peak noise periods during a time period to be identified and shows increases in intrusive noise sources. Leq intervals can be used to more accurately describe the effects of increased traffic in the project vicinity.

Variable noise is described as the level exceeded for a portion of the time. Thus, the L25 is the level exceeded 25 percent of the time during the sample period and L90 is the level exceeded 90 percent of the time and usually corresponds to the background sound level. Construction type equipment produces a fairly steady sound level so that the L25 is not appreciably different than the Leq or average sound level.

7.2.1.3 Attenuation

As a sound wave travels away from the source, the energy is dissipated in space and absorbed by the environment. The impact of a noise source depends on both how inherently loud the source is and how far away the receptor is from the source. For community noise analysis, the inherent loudness of a source is indicated by giving its sound level measured at a reference distance such as 50 or 100 feet from the source; this allows the level at other distances to be calculated.

Theoretically, the sound level drops by 6 dB with each doubling of distance from a stationary noise source. For a roadway line source, attenuation is 3 dB for distance doubling. Over long distances, there is also a loss of 1 dB for each 1,000 feet due to air adsorption.

In actual experience, sound is often more attenuated because of non-reflective ground, intervening dense vegetation, or topographic and structural barriers. With line-of-sight transmission in open country, attenuation proves to be somewhat greater than theoretical loss due to absorption of soft ground and approaches 9 dB per doubling of distance for point sources and 4.5 dB for line sources.

Terrain has a significant attenuating effect. An earth berm such as a hill or the edge of a terrace close to the source and projecting more than 20 feet past the line-of-sight will add as much as 20 dB loss to the attenuation from free-field distance effects. Vegetation absorbs sound in proportion to its density. A thinly planted screen has little attenuation effect, but a 100-foot deep strip of woodland will adsorb 10 to 20 dB of acoustic energy as the tree trunks cumulatively obscure direct transmission and increase sound loss.

7.2.2 Sensitive Receptors

Sensitive noise receptors are defined as locations such as residences, hotels, motels, hospitals, schools, churches, libraries, and parks where a quiet environment is essential and people would be adversely impacted by a loud noise environment. As a whole the national forest trail systems are fairly isolated and not near communities where many of these noise sensitive receptors would occur. There are occasional residences located on private property intermixed with the national forests such as occurs in Shasta National Forest. Some national forests also have resort lodges near the trails which cater to recreation visitors year-round such as the Ponderosa Lodge and Montecito Sequoia Lodge in Sequoia National Forest. Visitors to these resort lodges would be considered sensitive to the noise environment around them.

In addition, non-motorized users of the national forest trail system such as skiers and snowshoers would be sensitive noise receptors. Non-motorized trail users are typically sensitive to the aesthetics of their surroundings and find noisy activities intrusive to their enjoyment of the forest experience.

7.2.3 Ambient Noise Levels

Sound levels are usually measured and reported in dB, a unit which describes the amplitude, or extent, of the air pressure changes which produce sound. The A-weighted sound level or dBA is an adjusted or weighted measure of sound that corresponds to human hearing since the human ear cannot perceive all pitches or frequencies equally well. The Leq is used to describe noise levels over extended periods of time, unlike the dBA, which describes a noise level at just one moment. Background noise levels in undeveloped areas, such as open space recreational areas of national forests, are typically in the range of 35 to 45 dBA Leq. These noise levels are fairly quiet and reflect the surrounding natural forested land use. Sounds other than those naturally occurring in the forest during the winter include the sound of vehicle traffic on local roads and highways, aircraft overflight, and motorized vehicles on groomed trails.

The significance of a noise increase largely depends on ambient noise levels. A 3 dBA increase is barely perceptible and a 6 dBA increase is clearly audible. An audible increase in noise is generally significant if the proposed project activity causes noise standards to be exceeded.

7.3 PROJECT IMPACTS

7.3.1 Thresholds of Significance

According to Appendix G of the CEQA Guidelines, a project will normally have a significant effect on the environment if it will result in:

- Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies.

- Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels;
- A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project;
- A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project.

Project activities of snow removal, trail grooming, and OSV recreation do not generate or expose people to groundborne vibration or groundbourne noise levels. Therefore this issue is not further analyzed in this chapter.

7.3.2 Project Baseline, Year 2010

7.3.2.1 Noise Levels in Excess of Established Standards

Snow Removal and Trail Grooming. Snow removal and trail grooming involves the operation of heavy equipment which generates noise. These project activities began occurring in the Project Area on a seasonal basis between 1982 and 1996 and would continue in 2010 at these baseline levels. Noise associated with the Project is seasonal and episodic. Direct noise emissions generated by OSV Program operations include operating snowplows and blowers for snow removal from roads and parking areas and operating snowcats for trail grooming. Equipment operation begins in mid-December with snowfall and lasts through March dependent upon site location and snow conditions. The frequency of plowing and grooming is weather dependent. Plowing typically occurs along road segments on average once per week during daylight hours for up to 8 hours per day. Trail grooming occurs during nighttime hours up to three times per week on some trail segments and up to 12 hours per day (see Project Description, Table 2-2).

Equipment operation raises ambient noise levels in the immediate project vicinity. Noise generated by typical construction equipment (backhoe, excavator, grader) ranges from 80 to 85 dBA and represents the noise levels that can be expected from snowplows and snowcats used for OSV Program operations. Typical hourly average noise levels from this equipment are 75 to 80 dBA at a distance of 100 feet. These noise levels drop off at a rate of 6 dBA per doubling of distance between the noise source and receptor. Due to its soft surface, snow absorbs sound and thus further dampens equipment noise levels. These activities are not considered to have significant noise impacts because they are periodic, and not constant in one place, thus their contribution to the overall Ldn (day/night average noise level) would be less than significant.

Non-motorized trail users (skiers and snowshoers) are considered sensitive receptors to noise generated by the OSV Program activities. Trail grooming occurs during nighttime hours and is unlikely to impact this group of sensitive receptors. Snow removal on roads and trail heads occurs during daylight hours when non-motorized recreationalists would be using the trail system. If the trail users happened to be near roads and trailheads when snow removal was occurring, it is likely that they would find the noise loud and intrusive but would associate it with normal road maintenance operations. However, the noise impact from the removal equipment is localized to the roads and trailheads and would not impact sensitive receptors once they moved away from the trailhead area. Additionally, snow removal occurs only periodically and is not a constant noise source to the sensitive receptors. Thus, noise impacts from snow removal and trail grooming on sensitive receptors does not expose receptors to prolonged periods of excessive noise levels.

The noise levels generated by these activities are not subject to regulation by USFS S&Gs. Noise standards found in local general plans or noise ordinances do not apply to the Project Area which is located on federal land in national forests. Thus, noise generated by snow removal and grooming operations of the Project would not expose people to or generate noise in excess of established standards. Given that existing noise levels generated by snow removal and trail grooming operations are not excessive, and continuation of the OSV Program at 2010 baseline levels would not increase noise from these activities above historical levels, the impact is considered less than significant.

Passenger Vehicle Traffic. Noise from Passenger vehicles traveling to the Project Area for winter trail recreation would be audible to receptors in the Project Area near roads and trailhead parking areas. Noise levels generated by passenger vehicles at trailheads is less than the 75-80 dBA road noise typical for commercial roads (Table 7-1) due to lower traffic volume and slower vehicle speeds associated with parking areas. There are no ambient noise standards governing recreational activities in national forests and therefore passenger vehicle noise does not exceed established standards and is not considered significant. Continued operation of the OSV Program at 2010 baseline levels would not increase noise levels associated with passenger vehicle traffic in the Project Area above historic levels; the impact is therefore less than significant.

OSV Use. OSV use is allowable in national forests as designated by the governing LRMP. The audibility of the OSV is largely affected by atmospheric conditions, the terrain and vegetation surrounding the trail routes, the speed of OSV travel, and the number of OSV users. The Project facilitates OSV use along trail routes that have been previously used for wintertime recreation including motorized vehicles. At current OSV use rates, the OSV Program at 2010 baseline levels would not generate an increase the ambient noise levels associated with OSV use above historical seasonal levels.

Noise from snowmobiles manufactured after June 30, 1976 have a noise emission of 73 dBA at 50 feet while traveling at 15 mph when tested under SAE J1161 procedures. This is the equivalent of a single passenger vehicle or motorcycle on a roadway. A snowmobile under full throttle emits the same sound level as a truck pulling a camper at a constant highway speed applying very little throttle. In a worst case scenario, a snowmobile leaving a stop sign and applying full throttle, the noise produced is still about the same as a passenger vehicle driving down the road (International Snowmobile Manufacturers Association 2008). The effect is audible but not long lasting.

Noise levels generated by OSVs in the Project Area are not subject to regulation by local general plan or noise ordinance given the location on federal land in national forests. National forest LRMPs do not have S&Gs which restrict noise levels of OSV recreation. Thus, OSV use facilitated by the OSV Program would not occur in excess of established standards.

In the Project Area, OSV noise occurs in a recreation area open for OSV use. Because the activity is occurring in a trail system area designated for motorized use, the noise is expected by other trail users as part of the ambient noise conditions and therefore does not conflict or substantially detract from the recreational experience of other trail users.

Noise from OSV use is audible to other users on the recreation trail, which may include cross-country skiers and snowshoers. OSV use is restricted to specific trail locations in order to minimize conflicts between uses. OSV trails are signed to indicate that OSV use is permissible on these trails. Non-motorized users of the trail system know in advance that OSV use occurs on and off the trails in the Project Area and that project trails do not offer protection from intrusive sights or sounds of snowmobiles. Non-motorized trail users who might be sensitive to OSV noise have the option of choosing to recreate in areas closed to OSVs. Continuation of the OSV Program at 2010 baseline levels would not expand OSV use into new areas presently unused by OSV or promote OSV infringement upon quiet areas reserved for non-motorized users such as Nordic skiers and snowshoers. OSV intrusion into closed quiet wilderness areas adjacent to the groomed trails does occur as described in Land Use Plans and Policies, Section 3.3.3.1. Continued and enhanced enforcement of closed area boundaries is required as project mitigation (Measure LU-1) for OSV intrusion into wilderness areas.

Given the 1,761 miles of groomed trails provided by the OSV Program, the quick dispersal rates between the motorized and non-motorized user groups, and the access to wilderness areas from groomed trails which are available exclusively to non-motorized use, the current noise impacts of OSV use on non-motorized users in the Project Area is considered less than significant. Continuation of the OSV Program at 2010 baseline levels would not expose sensitive receptors to increased noise levels above existing conditions and is therefore considered a less than significant impact.

7.3.2.2 Substantial Permanent or Temporary Increase in Ambient Noise

Snow Removal and Trail Grooming. Existing noise associated with plowing and grooming operations is intermittent and seasonal. It is highly localized and does not substantially increase ambient noise levels in the surrounding environment (see Section 7.3.2.1 above). Continuation of the OSV Program at 2010 baseline levels would not increase snow removal and grooming equipment operations above existing levels and would not result in a substantial permanent or temporary increase in ambient noise and is therefore a less than significant impact.

Passenger Vehicle Traffic. As described in Section 7.3.2.1 above, noise levels associated with passenger vehicle traffic visiting the project trailheads is less than significant. OSV Program operations at 2010 baseline levels would not increase passenger vehicle traffic above existing levels and is therefore would not cause a substantial permanent or temporary increase in ambient noise. Therefore, the impact of the OSV Program at 2010 baseline levels on ambient noise from passenger vehicle traffic is less than significant.

OSV Use. The nature of OSV noise emissions is temporary and periodic because of the nature of the activity. As described in Section 7.3.2.1 above, snowmobiles manufactured after June 30, 1976 have a noise emission of 73 dBA at 50 feet while traveling at 15 mph. This level of noise emission is considered loud but because the OSV use is periodic and occurring in designated areas where the activity is known to occur, the noise impact it is not considered a substantial permanent or temporary increase in ambient noise. Under the Project Baseline, Year 2010, OSV use is not expected to increase measurably and the noise generated by current use levels would continue at the same level. Therefore the impact is less than significant.

7.3.3 10-Year Program Growth, Year 2020

7.3.3.1 Noise Levels in Excess of Established Standards

Expanded Trailhead Parking. New plowing to open the Four Trees trailhead would occur on the Oroville Quincy Highway which is presently closed during the winter season. Snow removal would occur intermittently as determined by snow fall conditions and would likely require 500 hours of equipment operation per season. Based on existing operations at Bucks Lake (Table 2-7), snow removal on the Oroville Quincy Highway and Four Trees trailhead would likely occur on 60 days of the season. Passenger vehicle travel associated with opening the Four Trees trailhead would be 20 round-trips on a maximum day based on parking capacity. Snow removal and passenger vehicle travel on the road would periodically increase the noise levels along this 10-mile stretch of road and at the trailhead while snow removal equipment was in operation and passenger vehicles pass through. Due to the low traffic volume, the episodic use of snow removal equipment, and the continual movement of the equipment along a road corridor, noise from these sources would not occur at levels that exceed noise levels expected along a rural highway corridor. There are no noise standards governing outdoor ambient noise levels in national forests; therefore the noise levels associated with opening the Four Trees trailhead for OSV access to Bucks Lake is not significant.

Increased snow removal operations needed to serve an expanded parking area at the China Wall trailhead is minimal. Snow removal at China Wall presently occurs on 15 days of the season for a total of 32 hours. Doubling the size of the parking lot would not appreciably increase operating hours of snow removal equipment from 2010 baseline conditions. Increased parking capacity would increase passenger vehicle traffic on Foresthill Road by 30 vehicles (round-trips) on a maximum day. Trips would be dispersed throughout the day. Due to the low volume of traffic generated by the trailhead expansion and the minimal increase in snow removal operation that would occur, the noise impact from trailhead expansion would not exceed noise levels expected for rural roads or outdoors environments. There are no noise standards governing outdoor ambient noise levels in national forests; therefore the noise impact of snow removal and subsequent vehicle use of the expanding China Wall trailhead is not significant.

Increased Grooming at Existing Trails. A modest increase in grooming hours may occur on any of the existing trail systems over the next 10 years. Up to 500 new grooming hours would be dispersed throughout the Project Area equating to two extra grooming days per season at each trail system. This would not result in a substantial increase in ambient noise levels above 2010 baseline conditions. There are no noise standards governing outdoor ambient noise levels in national forests and no sensitive receptors are affected by grooming activities; therefore, the impact of increased grooming operations anticipated over the 10-year program period is not considered significant.

New Trail Systems. Three new trail system locations (Lake Davis, State Route 4, and Bass Lake) have been identified for possible inclusion in the OSV Program by 2020. Snow removal already occurs at three of the four locations (Lake Davis and Bass Lake) and therefore no new noise impacts would occur from continued plowing or passenger vehicle traffic at these locations. New plowing operations would be required on State Route 89 south of Markleeville to service a new trailhead at State Route 4. Periodic plowing on a highway would not elevate noise levels beyond those expected for a highway. Passenger vehicle traffic on State Route 89, would be increased by 30 round-trips based on trailhead parking capacity. Because of the low traffic volume and the dispersal of vehicle trips throughout the day, the passenger traffic associated with the trailhead would not substantially elevate ambient noise levels; the traffic noise impact is less than significant.

Grooming operations do not generate a substantial increase in ambient noise levels as described above in Section 7.3.2.1. Grooming occurs at night and the snow surface absorbs sound. Because trail grooming is periodic and the equipment does not stay in one constant place, its contribution to the overall noise environment at these new locations would be less than significant.

See Section 7.3.2.1 above regarding noise levels from OSV use. National forests do not have S&Gs which restrict noise levels of OSV recreation. Thus, OSV use facilitated by the OSV Program at the new trail sites would not occur in excess of established standards.

As discussed in the Introduction (Section 1.2), site-specific impacts of developing new trail sites would be subject to environmental review under CEQA as a separate project.

Growth in OSV Recreation. The continuation of OSV recreation at the historical 4% growth rate would result in an increase of OSV use in the Project Area from 159,000 to 235,000 OSV seasonal-use days. This increase of 76,000 vehicles would be dispersed throughout the 26 trail systems in the Project Area over a 14-week season. OSV use on the average trail system would be increased by 209 riders per week. Elevated noise levels would occur in the immediate area of OSV use. Because OSV use at any given trail site is dispersed over miles of groomed trail and riding area, the noise generated by the OSVs are not concentrated and would not create a substantial increase in ambient noise levels at any given location. No ambient noise level standards apply to outdoor recreation in national forests. Therefore the impact is less than significant.

7.3.3.2 Substantial Permanent or Temporary Increase in Ambient Noise

Expanded Trailhead Parking. Snow removal on Oroville Quincy Highway to open the Four Trees trailhead and subsequent vehicle traffic on the highway would generate new vehicle noise on the highway during winter months. Likewise, an expansion of the China Wall trailhead parking capacity would accommodate increased vehicle trips on Foresthill Road. As described in Section 7.3.3.1 above the number of vehicle round-trips associated with the increase in parking capacity at these trailheads would not generate a substantial increase in ambient noise. The trips would be dispersed throughout the day. The vehicle noise would be consistent with noise levels associated with rural road corridors. The impact of increased vehicle noise on ambient noise levels is less than significant.

Increased Grooming at Existing Trails. Up to 500 new grooming hours may occur on the existing trail systems over the next 10 years roughly equating to two additional grooming days per season on each trail system. The noise from the increased grooming hours would be dispersed across the groomed trail length during nighttime hours. This would not result in a substantial increase in ambient noise levels above 2010 baseline conditions. Therefore, the impact of increased grooming operations anticipated over the 10-year program period is not considered significant.

New Trail Systems. See Section 7.3.3.1 above.

Growth in OSV Recreation. Increased OSV use in the Project Area would elevate noise levels in the immediate area of use. OSV use would be dispersed and, as described in Section 7.3.3.1 above, would not substantially increase ambient noise levels. The impact is considered less than significant.

7.3.4 Cumulative Impact

Project activities occur in the Project Area during winter months when the ground is covered in snow, which limits the type of noise generating activities which can occur. There are no new activities planned or proposed which would cumulatively add to noise levels from project equipment or OSV use occurring in the Project Area.

7.4 MITIGATION MEASURES

No significant impacts related to noise were identified; no mitigation measures are necessary.

8.0 RECREATION

This chapter describes the opportunity for access to winter trail recreation created by the OSV Program and the potential conflicts between motorized and non-motorized users of the groomed trail system. Parking demand created at the trailheads is also discussed.

8.1 REGULATORY SETTING

8.1.1 California Department of Parks and Recreation, OHMVR Division

The OHMVR Division promotes managed, environmentally responsible and sustainable OHV use. OHMVR Division programs, including the OSV Program, are carried out with the advisory oversight of the OHV Commission and funded directly by the recreational community through OHV gasoline taxes, green and red sticker fees, and entrance fees at the State Vehicular Recreation Areas.

In partnership with federal and county agencies, the OHMVR Division administers motorized and non-motorized winter programs consisting of a system of trailheads and groomed trails for snowmobile use (OSV Program) and 19 sno-parks for non-motorized snow play such as sledding and cross-country skiing. Both the motorized and non-motorized programs offer parking areas cleared of snow, restrooms, and trash collection services.

The OHMVR Division makes grants and cooperative agreements available to local, state, and federal entities as well as non-profits, educational institutions, and federally recognized native American tribes. OHMVR Division staff ensures the appropriate use of these funds and help identify solutions to OHV-related issues. Environmental sciences staff review and monitor grant and cooperative agreement funded projects, focusing on the condition of soils and wildlife habitat, habitat restoration, and compliance with state and federal environmental laws.

The OHMVR Division provides education, training, and information to promote safe and environmentally responsible OHV recreation. The OHMVR Division also offers winter safety and snowmobile operation classes for children. The public safety program assists organizations providing OHV-related public safety to identify issues, encourage cooperation, and facilitate solutions. Marketing and outreach promotes widespread understanding of environmental protection and safe and appropriate OHV recreation.

8.1.2 California Recreation Policy

California's Recreation Policy (CDPR 2005) broadly addresses the full range of active, passive, indoor and outdoor recreation activities throughout the state. This comprehensive policy is directed at recreation providers at all levels: federal, state, and local agencies, as well as private and nonprofit suppliers. Of particular relevance to the Project are the policy's emphasis on opportunity and access for all recreation activities and populations, while preserving natural and cultural resources.

8.1.3 California Outdoor Recreation Plan

The 2008 California Outdoor Recreation Plan (CDPR 2009) identifies the state's most critical outdoor recreation issues in the next five years and lays out a strategy by which state, federal, and local agencies might best address them. The plan identifies as California's foremost strategic priority projects that provide opportunities for the top 15 outdoor recreation activities identified in public opinion surveys. OHV use ranked tenth in the top 15 outdoor recreation activities. OSV use is not specifically called out in the survey, issues or actions.

8.1.4 U.S. Forest Service

The USFS is a key provider of recreation in California. There are 18 national forests in California covering over 20.6 million acres, or one-fifth of the state's total area. Portions of 11 of these national forests are within the Project Area. The USFS employs multiple-use and sustained yield principles to manage these lands, while accommodating a variety of uses, including outdoor recreation, timber, grazing, watershed management, fish and wildlife habitat and wilderness. The multiple uses fit within an ecosystem framework approach. The USFS provides about half of the wildland recreation opportunities in California. In 2007, there were 31 million recreation visits to the state's national forests.

Land Resource Management Plans. Each national forest is managed under a LRMP. The LRMPs designate areas as open, restricted, or closed to OHV/OSV use. OSV use is prohibited in areas classified as wilderness, primitive, or semi-primitive non-motorized. Additionally, seasonal closures and designated trails may be used to mitigate impacts from OHV use. Relevant LRMP forest-wide S&Gs and management prescriptions are discussed in detail in Land Use Plans and Policies (Section 3.0) and in Appendix D, Tables 1 and 2.

Travel Management. The USFS identified unmanaged recreation, especially impacts from OHVs, as one of the key threats facing the nation's forests. National forests throughout California have been working since 2003 with the motorized, environmental, and non-motorized communities to implement the 2005 national travel management rule. The effort will prohibit cross-country motor vehicle travel in the national forests and result in the publication of a Motor Vehicle Use Map (MVUM) for each national forest. This map designates the roads, trails and areas open to public motor vehicle use.

National Forests throughout California have been working with the motorized, environmental, and other non-motorized communities to identify roads, trails and areas that are appropriate for motor vehicle use. National Environmental Policy Act (NEPA) decisions and MVUMs represent the first-step in the travel management rule's long-term objective to improve management, reduce the environmental impacts associated with motor vehicle use, and develop a sustainable system of roads, trails and areas for public motorized use.

There are three parts to the Travel Management Rule: Subpart A (Administration of the Forest Transportation System), Subpart B (Designation of Roads, Trails and Areas for Motor Vehicle Use), and Subpart C (Use by Over Snow Vehicles). The national forests in California have been working to complete Subpart B, which affects motor vehicle use on national forest system lands. Sixteen of the eighteen national forests have completed their Final Environmental Impact Statement (EIS) and Record of Decision (ROD). By the publication of this EIR the two remaining national forests will also have completed their Final EIS and ROD. Although the travel management rule provides the framework for designating over-snow vehicle use, the impacts from cross-country use of snowmobiles present a different set of management issues than cross-country use of other types of motor vehicles. The need to allow, restrict, and prohibit over snow vehicles and over snow travel will be accomplished as needed, on a case-by-case basis, throughout the national forests of California.

<u>OSV Trail Maps.</u> The national forests provide OSV guide maps that indicate where OSV use is appropriate and allowed. These maps also highlight the specific groomed and non-groomed trails available for use and may also call out particular prohibitions or hazards. OSV guide maps are available at Ranger District offices, trailhead kiosks, and national forest websites. Winter recreation opportunity guides may also be available. These guides broadly explain opportunities, rules and hazards for OSVs and other types of winter recreation. Trail systems groomed as part of the OSV Program are shown in Figures 2 through 12.

8.2 Environmental Setting

8.2.1 National Forest Winter Recreation Trends

There has been a steady and continuing increase in winter recreation nationwide, in California in particular, and on national forest lands. This increase is attributable to a number of factors, including general population growth, enhanced opportunity and access, more capable equipment, and the growing popularity and new varieties of outdoor recreation pursuits.

The USFS has recently used the National Visitor Use Monitoring (NVUM) program to obtain recreation participation data for each national forest. The NVUM data provides information about the type, quantity, quality and location of recreation use on national forest system managed lands at the national, regional, and forest level. Estimated site visits in the 11 national forests participating in the OSV Program total 17.7 million (Table 8-1). A site visit is defined as the entry of one person into a national forest site or area to participate in recreational activities for an unspecified period of time. The site visit ends when the person leaves the site or area for the last time on that day. Annual snowmobile and cross-country ski and snowshoe visits for each of the national forests in the Project Area is presented in Table 8-1 based on NVUM data collected between 2005 and 2008. The NVUM data highlighted the popularity of both motorized and non-motorized winter recreation in California, with 448,000 total annual snowmobile visits and 610,000 cross-country ski visits throughout the 11 national forests. There were roughly 36% more cross-country ski and snowshoe visits than snowmobile visits. Cross-country ski and snowshoe visits outnumbered snowmobile visits in seven of the 11 national forests. Modoc, Plumas and Tahoe National Forests saw more snowmobile than cross-country ski/snowshoe visits. On the Stanislaus National Forest, snowmobile and cross-country ski/snowshoe visits were equal.

The number of registered snowmobiles in California has increased at compounded annual rate of four percent in recent years, from approximately 14,000 in 1997 to 22,499 in 2009, according data from the OHMVR Division and the DMV (CDPR 1998, DMV 2009). Based on the historic growth rate in the number of snowmobiles registered in California each year (see Project Description, Section 2.6.2), it is estimated that the number of snowmobiles registered in California could increase by roughly 48% by 2020.

Table 8-1. Annual Winter Recreation Visits in California National Forests Participating in OSV Program

National Forest	Total Estimated Site Visits	Snowmobile	Cross-Country Ski and Snowshoe
Klamath	338,800	13,891	54,547
Modoc	178,100	70,171	0
Shasta-Trinity	1,455,300	1,455	11,642
Lassen	1,556,900	21,797	43,593
Plumas	743,700	63,958	12,643
Tahoe	2,082,300	158,255	104,115
Eldorado	1,898,800	7,595	64,559
Stanislaus	2,100,300	37,805	37,805
Inyo	5,082,300	55,905	233,786
Sierra	1,424,900	17,099	39,897
Sequoia	819,700	0	7,377
Total	**17,681,100**	**447,932**	**609,965**

Source: USFS 2009d-n

8.2.2 OSV and Non-Motorized Recreation Opportunity and Access

The national forests provide winter recreation opportunities for both motorized and non-motorized recreation, on groomed trail systems and throughout the open areas of the forests. All trails and off-trail open areas of the national forests are open to non-motorized recreation. OSVs are prohibited from using non-motorized trails and OSV use is prohibited in areas classified as wilderness, primitive, or semi-primitive non-motorized. There may be further seasonal and temporary restrictions on OSVs used to protect natural resources. While most non-wilderness areas are legally open for snowmobiling, in practicality steep terrain, lack of snow, and poor access substantially limit areas available to OSV use.

Table 8-2 shows the miles of groomed trails and acres of off-trail open areas open to both motorized and non-motorized recreation (multi-use), and those trails and lands open to non-motorized recreation only. The table shows all multi-use trails as well as those multi-use trails that would be groomed as part of the Project. Non-motorized, non-wilderness, off-trail areas are shown separately because in winter, the distances from plowed parking areas and trailheads can make wilderness areas inaccessible to skiers and snowshoers, so non-motorized, non-wilderness represents the true practical recreational opportunity. As shown in Table 8-2, the OSV Program is the primary provider of groomed trails. Private businesses provide groomed trails in two national forests included in the OSV Program (Tahoe and Inyo National Forests). Additionally, a private concessionaire grooms 25 miles at the Hope Valley Sno-Park (Humboldt-Toiyabe National Forest). The remaining national forests in the Project Area have no other groomed trails which allow motorized use. Outside of the OSV Program, the national forests provide 162 miles of non-motorized groomed trails available for skiers and snowshoers. Additionally, there are approximately 8.9 million acres of off-trail lands designated multi-use and 3.3 million acres designated for non-motorized use only.

Table 8-2. Winter Recreation Opportunity in California National Forests

National Forest	Snow Program Groomed Trails (miles)	Other Motorized Groomed Trails[1] (miles)	Non-motorized Groomed Trails (miles)	Ungroomed Trail[2] (miles)	National Forest Total Acreage	Open to OSV and Non-motorized[3] (acres)	Wilderness Non-motorized Only (acres)[4]	Non-Wilderness Non-motorized Only (acres)[5]
Klamath	135	0	12	335	1,700,000	1,260,836	410,164	29,000
Modoc	52	0	0	15	1,654,392	1,000,000	70,385	584,007
Shasta-Trinity	86	0	18	14	2,100,000	733,863	484,986	881,151
Lassen	402	0	18	n/a	1,200,000	418,000	77,881	70,119
Plumas	182	0	0	868	1,200,000	1,137,563	23,958	14,484
Tahoe	270	70	2	n/a	811,740	724,440	19,048	68,252
Eldorado	60	0	35	115	596,724	438,724	123,629	34,371
Stanislaus	70	0	30	796	898,099	539,885	212,537	145,677
Inyo	80	20	12	1000	2,070,000	1,030,000	990,000	50,000
Sierra	209	0	0	25	1,286,000	754,000	532,000	0
Sequoia	215	0	35	190	1,110,000	344,398	307,477	9,523
TOTAL	1,761	90	162	3,358	14,626,955	8,381,709	3,252,065	1,886,584

Notes:

[1] Groomed trail opportunities provided by private vendors. In Tahoe NF: Bowman Road (14 miles) track packed by Nevada Irrigation District to Bowman Lake; Rattlesnake Snowmobile Trail system (16 miles) groomed by Cisco Grove RV and Campground under agreement with USFS; Main Route (40 to 80 miles) grooming by volunteers on private land inholdings. In Inyo NF: Smokey Bear Flat (10 miles) groomed by DJ's Snowmobile Adventures; Crater Flat East (10 miles) groomed by Mammoth Snowmobile Adventures.

[2] Ungroomed trails on each NF include both marked and unmarked routes open to OSV and non-motorized use.

[3] Not all National Forest acreage technically open to OSV use is practically available for use due to low snow conditions, steep terrain, and poor access.

[4] Includes all National Forest areas except those classified in each forest's LRMP as wilderness, primitive, or semi-primitive non-motorized.

[5] Non-motorized non-wilderness is shown separately because in winter the distances from plowed parking areas and trailheads make most wilderness areas inaccessible to skiers and snowshoers.

Sources: USFS Response to OHVMR Division Data Request (USFS 2009). Winter Recreation on Western National Forest Land A Comprehensive Analysis of Motorized and Non-Motorized Opportunity and Access (Winter Wildlands Alliance 2006).

Although multi-use trails are open to both motorized and non-motorized recreationists, there is a certain degree of incompatibility between OSVs and cross-country skiers and snowshoers; OSV use on multi-use trails can diminish the quality of recreation experienced by non-motorized users by generating noise, exhaust, tracks, and potential safety conflicts.

A typical OSV user can travel a considerably greater distance than can a typical cross-country skier or snowshoer suggesting that, by their very nature, OSVs need access to more miles of trail and larger off-trail areas for a quality recreation experience as compared to skiers and snowshoers who have a more limited range. Until the 1990s, OSV use was generally restricted to groomed trails since early snowmobiles would easily become bogged down in deep snow. Today's more capable machines, with improvements in power, weight, traction, and fuel tank capacities, can access remote ungroomed parts of the national forests. Regardless of machine capability, the groomed trail system remains the focal point for most OSV users. A recent survey by the OHMVR Division (Appendix A) showed the majority of OSV users spent the majority of their time on groomed trails (Project Description, Table 2-9). Approximately 19 percent of those surveyed spent 60 to 100 percent of their time off-trail. The range for a snowmobile is typically 85 to 100 miles on groomed trails and 65-85 miles off-trail (based on public comments received at the May 20 and 21, 2009 Fresno, California scoping meeting for this EIR). This is consistent with a 1997 survey of OSV users (CDPR 2008) which show a typical range of 80 miles traveled per day (see Project Description, Section 2.6.1). A typical cross-country skier or snowshoer can cover approximately 10 miles on ungroomed snow in a day (Winter Wildlands Alliance 2006).

8.3 PROJECT IMPACTS

8.3.1 Thresholds of Significance

According to Appendix G of the CEQA Guidelines, a project would normally be considered to have a significant impact on the environment if it would:

- Increase the use of existing neighborhood and regional parks or other recreation facilities such that physical deterioration of the facility would occur or be accelerated; or
- Include recreation facilities or require the construction or expansion of recreational facilities, which might have an adverse physical effect on the environment.

To address the significance of the current and project future demand for groomed trail recreation, the following thresholds were used in addition to the CEQA thresholds identified above. Would the project:

- Create safety conflicts between motorized and non-motorized users of the trail system or quality of recreation experience conflicts for trail users such that additional facilities would need to be provided, the construction of which might have an adverse physical effect on the environment; or
- Create law enforcement or other public safety concerns at the trail system facilities.

8.3.2 Project Baseline, Year 2010

8.3.2.1 Physical Deterioration of Facilities

Under the 2010 baseline operating conditions, the OSV Program would not increase the use levels on the groomed trail system or trailhead parking facilities above existing levels. However, as discussed in Project Description, Section 2.6.1.2, plowing and grooming activities of the OSV

Program support higher OSV levels at trailheads than what would otherwise occur. This increased use level is reflected in the project baseline conditions evaluated in this EIR.

Seasonal OSV use of the Project Area is estimated at 158,000 (Project Description, Table 2-8). The groomed trail system funded by the Project comprises 1,761 miles of trail on 26 trail systems. These OSV Program facilities meet the current demand for multi-use trail recreation. The OSV Program requires that project trails are groomed at least once per week in order to remove ruts and maintain an even, hard surface which creates stable and smooth riding conditions. Historic OSV Program operations have been adequate to meet the current demand levels for maintained trails.

Current demands on trailhead parking areas have resulted in overcrowded trailheads and parking shortages (see Section 8.3.2.4 below). The heavy vehicle use at trailheads year-round has caused physical deterioration of the parking pavement at some of the trailheads. These trailheads are maintained by the USFS with state funding through the Grants Program.

8.3.2.2 Adverse Environmental Effect from Expanded Recreational Facilities

Under the 2010 baseline operating conditions, the OSV Program would not result in the construction or expansion of new recreation facilities. The potential for increased demand for winter trail recreation and possible construction or expansion of recreation facilities over the next 10 years is addressed in Section 8.3.3 below.

8.3.2.3 Conflicts between Motorized and Non-motorized Use

There is a certain degree of incompatibility between OSVs and non-motorized recreationists seeking a quiet, pristine natural experience. Snowmobiles are heavy machines capable of moving at high speeds. The machines have exhaust emissions and can be loud depending upon the engine type and the riding habits of the user. Given these characteristics, OSV use has the potential to impact non-motorized winter recreation in a number of ways.

Noise. Noise from OSVs can affect the quiet and natural sounds that are an important part of the experience cross-country skiers and snowshoers seek in the national forests. Two-stroke engine models, which accounted for 96 percent of all snowmobiles used by visitors surveyed in the OHMVR Division 2009 Winter Trailhead Survey, are noisier than four-stroke models. Additionally, some riders retrofit their machines with aftermarket parts to enhance performance; this can result in louder engine noise than the 82 dB standard specified by the CVC (see Noise, Section 7.3). Approximately 12 percent of snowmobiles belonging to visitors surveyed in the OHMVR Division 2009 Winter Trailhead Survey had altered mufflers or altered mufflers and engines (Appendix A, Table 24). Noise generated by the majority of OSV is 73 dB at 50 feet, which is slightly less than vehicle traffic (Table 7-1). Noise impacts from OSV use are dispersed throughout the trail system and open riding areas, and the noise effect is highly localized (see also Noise, Section 7.0).

Exhaust and Air Pollution. Exhaust from snowmobiles can accumulate at and near trailhead parking lots and on popular trails. Snowmobile exhaust contains pollutants that are hazardous to human health. Emissions from two-stroke engines, which accounted for 96 percent of all snowmobiles used by visitors surveyed in the OHMVR Division 2009 Winter Trailhead Survey, are greater than from four-stroke engines. As a mobile emission source, air quality impacts from OSV use are dispersed over the trail system and open riding areas and do not create hazardous concentrations of pollutant emissions. Given that skiers, snowshoers, and other non-motorized recreationists using the trail system area tend to recreate in areas separate from snowmobiles, they are unlikely to be significantly affected by concentrated exhaust emissions or strong odors (see also Air Quality, Section 4.0).

Safety Concerns. Snowmobiles typically weigh up to 600 pounds and many can travel at high speeds requiring longer stopping distances. Based on the OHMVR Division 2009 Winter Trailhead Survey, the average speed of OSV users on Project trails is 40 miles per hour, although riders maintain lower speeds at trailheads due to the concentration of other OSVs and non-motorized recreationists (Appendix A, Table 22) entering and exiting the trailhead parking area. Snowmobilers and skiers have different travel ranges, and the user groups tend to disperse quickly into separate areas without further interaction. Skiers and snowshoers have short ranges (5 mile radius from trailhead) and tend to get off the groomed trail quickly and stay within a few miles of the trailhead. OSV users have longer ranges (50 mile radius from trailhead) and travel farther down the trail before getting off into open riding areas. Participants in the Winter Trailhead Survey indicated that excessive speed of OSV users was not a problem (Appendix A, Table 26). Law enforcement information provided by the national forests did not identify excessive speed, alcohol and drug violations, or reckless driving as significant problems in response to CDPR's request for information.

Tracks. For many snowmobilers and skiers alike, the availability of freshly groomed trails or untracked off-trail terrain is key to a quality recreational experience. On the other hand, some skiers find OSV tracks make off-trail skiing easier. Groomed trails can become churned up or rutted by snowmobiles, making skiing more difficult (Winter Wildlands Alliance 2006). More frequent grooming can provide a smoother and more stable skiing surface. Grooming also improves access for search and rescue operations, and makes law enforcement and resource protection patrols easier.

Based on these factors, the existence of snowmobiles can result in some localized reduction in the quality of the recreation experience for non-motorized recreationists seeking a quiet, pristine natural experience. However, the groomed trail system funded by the OSV Program is an established multi-use trail system. Non-motorized users of the trail system know in advance that OSV use occurs on and off the trails in the Project Area and that project trails do not offer protection from intrusive sights or sounds of snowmobiles. The proposed OSV Program funding does not expand snowmobile use into new areas presently unused by OSVs or promote OSV infringement upon quiet areas reserved for non-motorized users such as Nordic skiers and snowshoers. OSV intrusion into closed wilderness areas adjacent to the groomed trails does occur as described in Land Use Plans and Policies, Section 3.3.3.1. Continued and enhanced enforcement of closed area boundaries is required as project mitigation (Measure LU-1) for OSV intrusion into wilderness areas.

Given the 1,761 miles of groomed trails provided by the OSV Program, the quick dispersal rates between the motorized and non-motorized user groups, and the access to areas from groomed trails which are available exclusively to non-motorized use, the potential conflicts between non-motorized and motorized users in the Project Area are low and considered less than significant. Very few problems were observed or experienced by surveyed visitors to the Project Area (Appendix A, Tables 31 through 42). Patrol logs provided by national forests in response to the OHMVR Division's request for data do not indicate a problem between trail user groups on the project trails (USFS 2009). The multi-use nature of the groomed trail system provided by the Project does not create conflicts between motorized and non-motorized user groups to the degree that additional recreation facilities should be constructed to separate user groups and reduce conflict.

8.3.2.4 Law Enforcement or Other Public Safety Concerns

Approximately half of the trailheads included in the OSV Program have somewhat frequent overflow conditions (see Table 8-3). Most overflow parking conditions occur on holiday weekends, sunny weekend days, particularly following a period of heavy snow, or during special events such as poker runs. The majority of overflow parking situations are contained within dead-end, plowed access roads and do not pose any potentially significant environmental, safety, or law enforcement concerns. Some trailheads, however, experience overflow-parking conditions that result in parking on highway shoulders with through traffic. Shoulder parking on these busy highways can present safety concerns; however, it is legal unless the vehicle is parked on the outside of the white fog line or is found to be “blocking.” California Highway Patrol will ticket and/or tow vehicles parked outside the fog line or blocking Caltrans plowing activities, emergency vehicle access to an adjacent site, etc.

The following trailheads have frequent overflow parking conditions that result in shoulder parking on busy, through-traffic highways: Huntington Lake (Sierra NF), Coyote (Sierra NF), Tamarack Ridge (Sierra NF), Kaiser Pass (Sierra NF), Lake Alpine (Stanislaus NF), Little Truckee Summit (Tahoe NF), and Shady Rest (Inyo NF, a non-program trailhead). Of these trailhead parking areas, only two trailheads were identified by national forests as posing potentially significant impacts to law enforcement and public safety: Little Truckee Summit and Shady Rest. Little Truckee Summit overflow parking occurs on the shoulder of State Route 89 and Shady Rest parking occurs up on the shoulder of Highway 395.

To determine the significance of potential impacts caused by parking overflow conditions a multi-step, qualitative process was used. First, trailheads having overflow conditions more than twice a year were identified. The national forest responsible for each trailhead was contacted to determine the nature of overflow parking conditions such as the location of overflow parking, the environmental or safety concern associated with the location of overflow parking, the intensity of the occurrence, the magnitude of the condition (how many vehicles), potential solutions that the national forests may be considering, and the significance of the problem as perceived by the national forests. Inadequate parking is in itself not considered a significant impact. The impact is considered significant where excess parking demand creates adverse environmental impacts or public safety impacts.

To assess the significance of impact to public safety and law enforcement at the Little Truckee Summit (Tahoe National Forest) trailhead and the Shady Rest trailhead (Inyo National Forest) which is no longer maintained by the OSV Program, California Highway Patrol (CHP) staff familiar with the area and the parking situation were interviewed. CHP officers were asked about the legality, safety, frequency, and magnitude of the problem. In the case of both trailheads, CHP officers stated that the parking is legal, safe, and is not considered a burden to law enforcement officials (Craig Muehleisen, pers. comm., 2010; Jeff Holt, pers. comm., 2010). Therefore, any perceived or real impacts created by overflow parking conditions at OSV Program trailheads were found to be less than significant. Therefore, under current trailhead use levels, the impact of parking demand exceeding parking capacity on law enforcement or public safety is not considered significant. The parking demand impact under increased trailhead visitor use over the 10-year program period is discussed below in Section 8.3.3.

Based on observed parking conditions reported by the national forests and follow-up interviews with national forest staff, it was determined that overflow parking conditions at OSV Program trailheads do not pose a significant impact to the environment, safety, or law enforcement.

Table 8-3. OSV Program Parking Demand, Baseline 2010

National Forest	Trailhead	Parking Capacity*	Weekday Demand	Max Day Demand	Overflow Frequency
OSV Program Trailheads					
Klamath	Deer Mountain	67	20	26	None
Klamath	Four Corners Medicine Lake	28	6	20	Special events
Modoc**	Doorknob	20	4	15	Rare
Shasta-Trinity	Pilgrim Creek	25	15	25	10x/season
Lassen	Ashpan	16	2	14	None
Lassen	Bogard	22	3	18	None
Lassen	Fredonyer	16	2	14	None
Lassen	Swain Mountain	20	4	16	None
Lassen	Chester-Almanor	50	6	20	Rare
Lassen	Morgan Summit	16	4	14	None
Lassen	Jonesville	12	4	10	None
Plumas**	LaPorte	25	5	50	Almost every weekend
Plumas**	Bucks Summit	75	15	110	Almost every weekend
Plumas**	Big Creek	25	5	40	Almost every weekend
Plumas	Gold Lake	20	3	80	8-12x/season
Tahoe	Bassetts	30	8	30	10-15x/season
Tahoe	Little Truckee Summit	35	17	140	Every weekend
Tahoe	China Wall	32	16	32	None
Eldorado	Iron Mountain	30	3	15	Occasional
Stanislaus**	Lake Alpine	120	24	120	Every weekend
Stanislaus**	Spicer Reservoir	80	16	80	Every weekend
Stanislaus	Highway 108	130	50	280	Holidays and sunny weekend days
Sierra	Huntington Lake	100	50	100	4x/season
Sierra	Tamarack Ridge	100	50	100	4x/season
Sierra	Kaiser Pass (Eastwood)	30	15	30	4x/season
Sequoia	Big Meadow	15	3	15	Some
Sequoia	Quail Flat	20	4	20	Some
Sequoia	Cherry Gap	6	1	3	None
Sequoia	Upper Woodward	4	1	2	None
Sequoia	Quaking Aspen	8	2	2	None
Sequoia	Holby (Ponderosa)	6	5	18	Weekends
Sequoia	Sugarloaf	10	5	5	None

Table 8-3. OSV Program Parking Demand, Baseline 2010					
National Forest	**Trailhead**	**Parking Capacity***	**Weekday Demand**	**Max Day Demand**	**Overflow Frequency**
Sequoia**	Kern Plateau-Westside	10	2	8	Holidays
Sequoia**	Kern Plateau-Eastside	4	1	3	None
	Subtotal	**1,207**	**371**	**1,475**	
Non-OSV Program Trailheads					
Tahoe	Old Gold Lake Highway	16	10	14	none
Tahoe	Yuba Pass Sno-Park	20	4	20	4-7x season
Tahoe	Prosser Hill	12	2	9	none
Sierra	Coyote	75	38	75	4x season
Inyo**	June Lake Hwy395/158	20	4	44	2x season
Inyo**	Obsidian Road/Hwy 395	40	8	78	3x season
Inyo**	Bald Mtn Road/Hwy 395	3	1	15	20x season
Inyo**	Deadman Creek/Hwy 395	3	1	8	10x season
Inyo**	Scenic Loop/Hwy 395	18	4	50	5x season
Inyo**	Shady Rest	40	8	100	20x/season
Inyo**	Deadman Hill Snowplay	15	3	74	22x season
Inyo**	Inyo Craters	4	1	13	25x season
Inyo**	Cinder Shed	5	1	11	16x season
Inyo**	Big Springs	2	0	6	10x season
Inyo**	Tioga Pass Road	8	2	13	25x season
Inyo**	Sherwin Creek Road	6	1	20	35x season
Inyo**	Mt. Morrison Cemetery Rd.	8	2	20	12x season
Sequoia	Greenhorn Summit	10	2	18	some
Sequoia	North Road	6	1	4	none
	Subtotal	**311**	**93**	**592**	
	Total	**1,518**	**464**	**2,067**	

Notes:
*Parking capacities vary dependent upon plowed conditions and the number of vehicles pulling trailers
** Weekday data not available. Weekday demand assumes 20% of parking capacity.

Source: USFS 2009; TRA Environmental Sciences, Inc. 2010

8.3.3 10-Year Program Growth, Year 2020

OSV use is expected to increase by roughly 48% over the OSV Program years 2010 to 2020 based on an historic annual growth trends (Project Description, Section 2.7.2.1). In response, growth in the OSV Program operations is expected.

8.3.3.1 Physical Deterioration of Facilities

Expanded Trailhead Parking. OSV use is expected to increase by roughly 48% over the 10-year program period based on an historic annual growth trends (Project Description, Section 2.7.2.1). The resulting increase in OSV use at each trailhead by 2020 is identified in Table 8-4. The USFS has identified expansion at one trailhead and opening of a second trailhead to accommodate use at two trail systems (Project Description, Section 2.7.1). The opening of the existing Four Trees trailhead (Plumas National Forest) for winter use at Bucks Lake would partially relieve the current chronic parking shortage experienced at the other two trailheads at Bucks Lake (Table 8-3) by adding 20 additional parking spaces. Likewise, the planned expansion of China Wall trailhead would add 30 parking spaces to that trailhead, which is at capacity.

The expanded trailhead facilities would facilitate either current or increased visitor use of the Bucks Lake and China Wall trail systems resulting in increased need for trail grooming. The OSV Program anticipates increasing its trail grooming operations system wide in order to maintain groomed trails and meet the increase in demand (discussed below). Therefore, increased demand on these groomed trail systems facilitated by expanded trailhead parking would be offset by increased grooming operations. The expanded trailheads would not result in a physical deterioration of the groomed trail system.

Increased Grooming on Existing Trails. A modest increase in grooming operations at existing trail sites is anticipated by the OHMVR Division over the next 10 years in order to maintain trails in good condition. The increase in grooming operation has the beneficial effect of maintaining the physical integrity of the groomed trail system and preventing deterioration of the trail.

New Trail Systems. Growth in state population will likely continue to increase demand for access to winter recreation throughout the state's national forests. Based on projected growth levels in OSV use over the 10-year project period, it can be expected that there will be more demand placed on the state to expand its trail facilities. Three new trail systems could be established by the OSV Program by 2020. Expansion of the groomed trail system to new locations would relieve user demand on the existing 26 trail systems currently operated by the OSV Program. The creation of new trail systems would not result in the physical deterioration of existing recreation facilities. To the degree that new trail systems reduce demand on existing trail systems, the new trails would have a beneficial effect of reducing grooming maintenance needs on existing trails. There are no immediate plans to establish these sites. Development of new trail systems would be subject to environmental review under NEPA and CEQA at the time of actual proposal.

Growth in OSV Recreation. The growth in OSV use to 2020 levels would place increased demand on the existing trail system. The existing weekly grooming frequency would be sufficient to maintain the integrity of the trail system and keep it in good riding condition without increased grooming services and new trail systems described above.

8.3.3.2 Adverse Environmental Effects from Expanded Recreational Facilities

Expanded Trailhead Parking. Growth in OSV Program operations anticipates the expansion of trailhead parking at two locations. Four Trees trailhead (Plumas National Forest) currently exists but is closed in winter and requires snow removal along Oroville Quincy Highway and at the Four Trees trailhead parking area. This would not result in adverse physical effects on the environment. Expansion of the China Wall trailhead (Tahoe National Forest) would double its parking capacity and requires environmental review under NEPA (Project Description, 2.7.1). Construction of the expanded parking is not proposed under the OSV Program. The OSV Program would provide snow removal services on this expanded parking area once developed. There are no adverse environmental effects associated with snow removal at the China Wall trailhead.

Increased Grooming on Existing Trails. Growth in hours of grooming equipment operations is anticipated in order to maintain the groomed surface on existing trails. Increased grooming is not an expansion of recreational facilities but rather a maintenance requirement for existing trails at established trail system locations.

New Trail Systems. Expansion of the OSV Program to provide three new groomed trail systems may occur during the 10-year program period. There are no immediate plans to establish these sites. Development of new trail systems would be subject to environmental review under NEPA and CEQA at the time of actual proposal.

Growth in OSV Recreation. Growth in OSV recreation creates a demand for expanded trailhead parking, increased grooming services at existing trails, and creation of new trails systems. Each of these actions is described above.

8.3.3.3 Conflicts between Motorized and Non-motorized Use

Expanded Trailhead Parking. Adding Four Trees trailhead to the OSV Program and expanding the existing China Wall trailheads would not affect the potential for conflicts between motorized and non-motorized users in the Project Area.

Increased Grooming on Existing Trails. Increased grooming frequency is anticipated in response to projected growth in OSV recreation in order to maintain the integrity of the groomed snow surface. The provision of a modest increase in grooming hours (up to 500 hours total for all trails combined) on existing trails during the 10-year program period would not affect the potential for conflicts between motorized and non-motorized users in the Project Area.

New Trail Systems. The same potential that exists for conflicts between motorized and non-motorized use on existing trails would exist at new trails established by the OSV Program during the 10-year program period being considered. See Section 8.3.2.3. Existing impacts are not significant and likewise it is expected that potential conflicts at new trail systems would be at a similar level and therefore not significant. The development of new trail systems for the OSV Program would be subject to environmental review under NEPA and CEQA.

Growth in OSV Recreation. The historical average annual OSV growth rate of 4% could result in a 48% increase in OSV use in Project Area from 159,000 to 235,000 by 2020. The groomed trails provided by the OSV Program are multi-use trails open to both motorized and non-motorized use. Growth in OSV recreation could increase the potential for conflict with non-motorized users of the groomed trail system. These conflicts are described above in Section 8.3.2.3 and would mostly occur within short range of the trailhead. On trails which have lower use levels, the increase in OSV riders would have a low potential for increasing conflicts between motorized and non-motorized users. For more popular trails that also have a higher degree of non-motorized use, an increase in OSV use would have a greater potential for conflict.

The USFS monitors recreational uses on the national forests through patrols by law enforcement and forest protection officers. Measure REC-1 requires ongoing USFS patrol of trailheads and trail areas to monitor for use conflicts. If monitoring shows that increased OSV use at a trail site has resulted in conflicts which create chronic public safety risks, the USFS and OHMVR Division shall implement necessary controls such as use restrictions, speed limits, segregated trail access points for motorized and non-motorized users, or public outreach. Implementation of Measure REC-1 would reduce the potential for conflicts between motorized and non-motorized user groups creating significant public safety risks to a less than significant level. Establishment of new non-motorized groomed trails within the Project Area is not contemplated under the OSV Program and would be a separate project subject to additional environmental review.

8.3.3.4 Law Enforcement or Other Public Safety Concerns

Expanded Trailhead Parking. Expanded trailhead parking at Four Trees and China Wall in itself does not create law enforcement or public safety concerns. Expanded trailhead parking would facilitate an increase in visitor use of the Bucks Lake and China Wall trail systems. The effect of increased OSV use at trail sites within the Project Area is addressed below in Growth in OSV Recreation.

Increased Grooming on Existing Trails. Increased grooming on the existing trail systems in the Project Area is anticipated in response to projected growth in OSV recreation in order to maintain the integrity of the groomed snow surface. Increased grooming frequency would not adversely affect law enforcement or create public safety concerns. Trail grooming helps delineate where it is legal to ride and helps to discourage incursions into areas closed to OSV use. Trail grooming also has the beneficial effect of hardening the snow surface to keep riders on safe snow conditions. This potentially reduces the number of responses to access violations and search and rescue operations.

New Trail Systems. Expanding the OSV Program to include new trail systems would result in increased demand on USFS law enforcement and forest protection officer staffing. Potential law enforcement issues and public safety concerns associated with new trails would be the same as for existing trails as described above in Section 8.3.2.4. New trail systems would be subject to environmental review under NEPA and CEQA. Law enforcement and public safety issues associated with the new trails would be addressed at that time.

Growth in OSV Recreation. Growth in OSV recreation would place increased motorized use in the Project Area and more vehicles and vehicles with trailers at trailhead parking areas. Law enforcement activities associated with the OSV Program typically involve enforcement of OSV vehicle licensing and safety rules, patrolling recreation boundaries (see Land Use, Sections 3.3.2.2 and 3.3.3.2), and public contact. Increased OSV use in the Project Area over the 10-year program period may necessitate an increase in law enforcement officer or forest protection officer presence at the trail sites to ensure these law enforcement activities are maintained at sufficient service levels. If adequate service levels are not maintained, potentially significant impacts to resources or public safety could occur. Continued monitoring by USFS personnel and increased staffing as needed is required by Measure REC-1 to meet the potential demands of increased visitor use. Implementation of Measure REC-1 would reduce the potential for inadequate public safety staffing levels to cause inadequate protection of public safety and resources to a less than significant level.

In addition to the potential safety concerns arising from motorized and non-motorized use conflicts (see Section 8.3.2.3 above), public safety issues can arise at trailheads due to a shortage of parking spaces. National forests are responsible for providing parking facilities at levels suitable to accommodate the desired forest carrying capacities. While demand may exceed capacity at some trailheads, it may be desirable from a forest management perspective not to increase parking capacities. The existence of excess parking demand is not itself considered a significant adverse impact; it is considered significant when it results in public safety concerns such as illegal or unsafe parking along heavily traveled access roads. At current use levels, excess parking demand has not created public safety concerns (see Section 8.3.2.3 above).

Increased parking demand associated with growth in trail use over the 10-year program period may create safety concerns that do not presently exist. Congested parking can block staging areas at trailheads for vehicle drop-off creating difficult access as described above in Section 8.3.2.3.

Various national forests are considering different ways to address overflow parking. These include parking lot expansion, new parking lots, plowing further into seasonally-closed winter roads, partnering with public or private entities to expand existing parking areas or creating new ones, and/or creating new parking areas for non-motorized recreation to alleviate pressure at OSV trailheads. Increasing parking capacities is not always feasible due to physical space limitations or national forest carrying capacity constraints. Measure REC-2 requires that USFS evaluate parking demand at trailheads where unsafe parking conditions are documented or anticipated due to growth and implement measures to address safety concerns. Development of new parking areas is not contemplated under the OSV Program and would be a separate project subject to additional environmental review.

Table 8-4. OSV Program Parking Demand, 10-Year Program Growth

National Forest	Trailhead	Parking Capacity*	Weekday Demand**	Max Day Demand**
OSV Program Trailheads				
Klamath	Deer Mountain	67	30	38
	Four Corners Medicine Lake	28	9	30
Modoc	Doorknob	20	6	22
Shasta-Trinity	Pilgrim Creek	25	22	37
Lassen	Ashpan	16	3	21
	Bogard	22	4	27
	Fredonyer	16	3	21
	Swain Mountain	20	6	24
	Chester-Lake Almanor	50	9	30
	Morgan Summit	16	6	21
	Jonesville	12	6	15
Plumas	LaPorte	25	7	74
	Bucks Summit	75	22	163
	Big Creek	25	7	59
	Gold Lake	20	4	118
Tahoe	Bassetts	30	12	44
	Little Truckee Summit	35	25	207
	China Wall	32	24	47
Eldorado	Iron Mountain	30	4	22
Stanislaus	Lake Alpine	120	36	178
	Spicer Reservoir	80	24	118
	Highway 108	130	74	414
Sierra	Huntington Lake	100	74	148
	Tamarack Ridge	100	74	148
	Kaiser Pass (Eastwood)	30	22	44
Sequoia	Big Meadow	15	4	22
	Quail Flat	20	6	30
	Cherry Gap	6	1	4
	Upper Woodward	4	1	3
	Quaking Aspen	8	3	3

Table 8-4. OSV Program Parking Demand, 10-Year Program Growth

National Forest	Trailhead	Parking Capacity*	Weekday Demand**	Max Day Demand**
	Holby (Ponderosa)	6	7	27
	Sugarloaf	10	7	7
	Kern Plateau-Westside	10	3	12
	Kern Plateau-Eastside	4	1	4
	Subtotal	**1,207**	**546**	**2,182**
Non-OSV Program Trailheads				
Tahoe	Old Gold Lake Highway	16	15	21
Tahoe	Yuba Pass Sno-Park	20	6	30
Tahoe	Prosser Hill	12	3	13
Sierra	Coyote	75	56	111
Inyo	June Lake Hwy395/158	20	6	65
Inyo	Obsidian Road/Hwy 395	40	12	115
Inyo	Bald Mtn Road/Hwy 395	3	1	22
Inyo	Deadman Creek/Hwy 395	3	1	12
Inyo	Scenic Loop/Hwy 395	18	6	74
Inyo	Shady Rest	40	12	148
Inyo	Deadman Hill Snowplay	15	4	110
Inyo	Inyo Craters	4	1	19
Inyo	Cinder Shed	5	1	16
Inyo	Big Springs	2	0	9
Inyo	Tioga Pass Road	8	3	19
Inyo	Sherwin Creek Road	6	1	30
Inyo	Mt. Morrison Cemetery Road	8	3	30
Sequoia	Greenhorn Summit	10	3	27
Sequoia	North Road	6	1	6
	Subtotal	**311**	**135**	**877**
	Total	**1,518**	**681**	**3,059**

Notes:
*Parking capacities vary dependent upon plowed conditions and the number of vehicles pulling trailers
**Assumes 4% average annual growth from 2010 Baseline levels

Source: USFS 2009; TRA Environmental Sciences, Inc. 2010.

8.3.4 Cumulative Impacts

There are no additional activities occurring in the Project Area which would create user conflicts on the recreational trails or create additional recreational demand on the groomed trail system. Parking demand at the trailheads during the 14-week project period (mid-December through March) is limited to visitors using the parking areas for winter recreation. There are no additional demands on trailhead parking space. No additional activities are occurring beyond those considered in this analysis which would create a cumulative demand for parking.

8.4 MITIGATION MEASURES

Implementation of the following mitigation would reduce potential project effects on public safety or resources to a less than significant level.

IMPACT: *Potential growth in OSV use levels projected over the 10-year program period may result in increased conflicts between motorized and non-motorized user groups. Such growth could also lead to a need for additional USFS law enforcement or forest protection officer staffing to ensure adequate public safety services.*

Measure REC-1: USFS shall continue to monitor trailheads and groomed trail areas for potential conflicts between motorized and non-motorized users in the Project Area. USFS shall ensure patrols occur with the necessary frequency needed to maintain adequate police and forest protection services. If monitoring results show conflicts between motorized and non-motorized uses cause chronic public safety risks, or that existing staffing levels are inadequate to maintain necessary public safety services, the USFS and OHMVR Division shall implement necessary site-specific controls to reduce safety risks such as trail use restrictions, speed limits, segregated trail access points for motorized and non-motorized users, public outreach providing maps and other information about alternative sites for non-motorized recreationists within the Project Area, or increased staffing.

Implementation:	By USFS and OHMVR Division
Effectiveness:	Site-specific controls would improve public safety and minimize potential conflicts between motorized and non-motorized users and ensure adequate protection of public safety and resources.
Feasibility:	Feasible
Monitoring:	National forests shall annually submit patrol logs showing monitoring and any site-specific measures, including enforcement actions, to OHMVR Division for agency review each summer prior to contract approval for OSV Program operations for the following winter season.

IMPACT: *Parking demand at trailheads serving the groomed trail system exceeds parking capacity at several locations. Currently, the excess parking demand is adequately controlled by national forest staff and California Highway Patrol so that illegal or unsafe parking conditions are minimized. Increased trailhead visitor levels over the 10-year program period without corresponding increases in parking capacities could increase the potential for unsafe parking conditions.*

Measure REC-2: Each national forest shall document to the OHMVR Division the opportunity and constraints for addressing unsafe parking conditions at trailheads where unsafe parking conditions are documented or anticipated due to growth. Measures to address such conditions may include signage, education, directing recreationists to under-utilized sites, and increased patrols with citations as appropriate. Where trailhead road widths permit, national forests shall establish designated unloading and loading zones and vehicle turnaround areas. National forests may consider increasing parking capacity through increased road shoulder plowing provided by OSV Program funding or coordination with Caltrans or county road departments where road widths can accommodate the parking.

Implementation:	By USFS and OHMVR Division
Effectiveness:	Establishing a protected unloading zone at trailheads, in conjunction with other possible measures, would improve safety of OSV users at congested trailheads.
Feasibility:	Feasible

Monitoring: National forests shall annually submit patrol logs showing monitoring and implementation of necessary actions at OSV Program trailheads to OHMVR Division for review each summer prior to contract approval for OSV Program operations for the following winter season. Documentation of opportunity and constraints for expanding trailhead capacity shall be submitted to OHMVR Division prior to start of 2012 winter season.

9.0 PROJECT ALTERNATIVES

CEQA Guidelines Section 15126.6 states that an EIR shall describe a range of reasonable alternatives to a project or location of the project which would feasibly attain most of the basic objectives of the project but would avoid or substantially lesson any of the significant effects of the project. The discussion of alternatives is to focus on alternatives that are capable of avoiding or substantially reducing any significant effects of the project, even if these alternatives would impede to some degree the attainment of the project objectives. Factors that may be taken into account when considering feasibility include site suitability, economic viability, availability of infrastructure, general plan consistency, other plans or regulatory limitations, jurisdictional boundaries, and whether the proponent can reasonably acquire, control, or otherwise have access to the alternative site.

9.1 CONSIDERED AND REJECTED ALTERNATIVES

Four alternatives have been identified and rejected from further consideration in the Project Alternative analysis due to infeasibility, not achieving project objectives, or not avoiding or substantially lessening an environmental impact. These alternatives are described below.

9.1.1 Alternative Project Locations

There are a total of 1,761 miles of trail groomed by the OSV Program throughout the Project Area. Additionally, there are 90 miles of groomed trail provided by private contractors and made available to the public for a fee in national forests participating in the OSV Program (Recreation, Table 8-2) and an additional 25 miles of privately groomed trail on the Humboldt-Toiyabe National Forest at Hope Valley Sno-Park. Thus, groomed trails funded by the State of California through the OSV Program represent 94% of the groomed trails available in the state. Each national forest in the OSV Program provides from 52 to 402 miles of groomed trail (Table 8-2). The trail routes have been established over the decades in areas deemed acceptable for OSV recreation by the forest plans (LRMPs) of each national forest. There are no other large land holdings outside the national forests which can accommodate this scale of OSV recreational use throughout the state. Therefore, there are no alternate trail systems in existence that are available to receive state funding as a replacement for the existing trail systems in the OSV Program. The OHMVR Division has identified possible locations for new grooming operations (Project Description, Section 2.7), but these locations are all within national forests and would only provide approximately 68 miles of groomed trail. Furthermore, establishing OSV use in new areas not already having OSV recreation could introduce new environmental impacts to those areas and would thus be inconsistent with the purpose of project alternatives under CEQA, which is to reduce or avoid significant environmental effects of the project.

9.1.2 Closure of Trail Systems

Closure of an entire trail system and its trailhead parking areas to winter recreation as a means of reducing significant project impacts such as OSV trespass issues, or potential damage to sensitive biological resources, represents an overly broad solution to very site-specific impacts. Under this alternative, entire trail systems would be closed in response to impacts on specific trail route segments or play areas rather than implementing protective measures focused at the point of impact. Given the relatively small scale of environmental impacts associated with the groomed trail system, closing an entire recreation area to address site-specific issues is unwarranted and would bring an unnecessary reduction in the winter recreation opportunities contrary to the OHMVR Division's project objective, which is to facilitate winter trail recreation in California.

9.1.3 Closure of Off-Trail Riding Areas

Restricting OSV use in national forests to designated groomed trails throughout the Project Area, similar to the restrictions in Giant Sequoia National Monument, could reduce environmental impacts associated with OSV use. However, the OHMVR Division is not a land manager of national forests and therefore does not have authority to restrict OSV use in national forests. OSV use in national forests is governed by individual forest LRMPs, and closure of off-trail riding areas would be inconsistent with existing LRMPs. Given that the OHMVR Division does not have authority to modify LRMPs or otherwise restrict OSV use in national forests, closure of off-trail riding areas is rejected as infeasible.

9.1.4 Prohibition of Two-Stroke Engines

As described in Air Quality, Section 4.3.2, the two-stroke engines are responsible for most of the emissions associated with snowmobile use. Four-stroke engines use less fuel and generate less noise, resulting in a cleaner and quieter ride. Banning the use of two-stroke engines on project trails in national forests is both infeasible and impractical. Two-stroke engines are legal in California, and banning their use puts the OSV Program and the national forests at odds with state law. National forests are open lands with ungated entry. There is no practical way of preventing two-stroke engines from accessing the project trails. Enforcement of this prohibition would be problematic. According to the Winter Trailhead Survey, 97% of the trail visitors used 2-stroke engines. The prohibition of two-strokes would place a heavy burden on the recreation community to replace their machines. While the switch from two-stroke to four-stroke could be beneficial for HC, CO, and PM emissions, it would increase NOx emissions (see Air Quality Section 4.3.2). The change is beyond the scale of the OSV Program project and would have to occur through state legislation and vehicle codes. For this reason, the prohibition of two-stroke engines in the Project Area is rejected from further consideration.

9.1.5 Shortened 10-Year Program Funding Period

Under this project alternative, the OHMVR Division would shorten the OSV Program funding period to less than 10 years. The OSV Program operations would remain the same as the Project, and OSV use levels would remain the same as for the Project. This alternative would not reduce the impacts of the OSV Program; the potential significant impacts identified for the Project (see Table S-1) and their cumulative impact would remain unchanged. As a result, this alternative does not accomplish the purpose of a project alternative as defined by CEQA, which is to reduce or eliminate significant environmental effects of the proposed Project, and is thus rejected from further consideration.

9.1.6 Funding of OSV Program through Grants Program

The 2002 BCP enabled the OSV Program to receive one million dollars of annual funding from the OHV Trust Fund through issuance of direct contracts to local counties and cost share agreements to national forests. Under this alternative, the OSV Program would no longer be funded through the BCP and would instead be returned to funding through the Grants Program.

Each county and national forest would be required to submit an annual application to the Grants Program for its funding needs. The applications would be considered along with summer OHV applications and awarded according to a competitive process. Under this alternative, the OSV Program would no longer have a dedicated source of funds provided through the BCP. Individual applications for grooming, plowing, and restroom maintenance may or may not be awarded dependent upon the scores of competing grant applications. Under this alternative, the OHMVR Division could only provide administrative oversight and ensure proper maintenance of snowcat equipment and consistency of trail grooming operations for those areas that received Grants Program funding. The efficiency and quality of the OSV Program would likely decline over time. Each national forest would be responsible for purchasing, maintaining, and operating snowcat equipment. The expense of the OSV Program could increase as the OHMVR Division would no longer control costs of equipment maintenance and fuel for snowcat operations program-wide through a negotiated contract with a single vendor. This alternative does not meet the project objectives of facilitating OSV recreation and does not meet the purpose of a project alternative under CEQA, which is to reduce or eliminate significant environmental impacts of the proposed Project. Therefore, this alternative is rejected from further consideration.

9.2 NO PROJECT ALTERNATIVE

Under the No Project Alternative, the OHMVR Division would not issue contracts to the 11 national forests and three county agencies, and the OSV Program would be discontinued. The one million dollar budget established for the OSV Program under the 2002 BCP (see Project Description, Section 2.9.1) would revert to the OHV Trust Fund. Grooming would not occur on 1,761 miles of trail, and plowing of 97 miles of access road as described in Project Description Table 2-6 would not occur. It is possible that funding from national forests and/or private sources, along with volunteer efforts, could be generated to preserve limited grooming or plowed access in some trail locations. But for the EIR analysis, the No Project Alternative assumes all grooming and plowing funded by the OSV Program would cease. Access to 21 of the 26 trail systems, provided by 27 trailheads currently plowed by the OSV Program, would no longer be plowed as shown in Table 9-1. Access to the remaining 5 trail systems from 7 trailheads plowed by Caltrans at sno-parks (Project Description, Table 2-6) would continue unaffected. The state highways adjacent to many of these trailheads would continue to be plowed by Caltrans, and therefore some trailheads could continue to be used as access points. Restroom and refuse collection service funded by the OSV Program (Table 2-1) would also no longer be available.

Visitor use of the trails would likely drop by half and as much as two-thirds based on the visitor trailhead survey. At least one-third of current OSV use is likely to continue (Project Description, Section 2.6.1.2). Groomed trails favor beginner riders who prefer a stable and predictable snow surface. Experienced riders who are more comfortable in softer, off-trail snow conditions would be more likely to continue riding in the Project Area without groomed trails. The projected growth in OSV Program operations (Project Description, Section 2.7.1) would not occur and growth in OSV recreation, if it occurs, would likely be substantially less than the historical 4% average annual rate projected (Project Description, Section 2.7.2.1).

<u>Land Use Plans and Policies</u>. Trespass incidents described in Land Use Plans and Policies, Section 3.3.2.2, would be reduced by the No Project Alternative given the smaller number of OSV users on the trail system. However, the availability of groomed trails is not a prerequisite for OSV use or for trespass. As documented in Land Use Plans and Policies Table 3-2, intrusion into protected wilderness, administrative closure areas, and private property happens apart from

the OSV Program groomed trail system. Intentional wilderness trespass occurs in ungroomed snow conditions. Therefore, it is unlikely that willful trespass would be eliminated by eliminating groomed trails under the No Project Alternative.

Table 9-1. Trailheads Not Plowed Under the No Project Alternative

National Forest/Trailhead	Groomed Trail Mileage
Klamath/Deer Mountain and Four Corners	135
Modoc/Doorknob	52
Shasta-Trinity/Pilgrim Creek	86
Lassen/Ashpan	35
Lassen/Bogard	80
Lassen/Swain Mountain and Chester Lake Almanor	60
Lassen/Fredonyer	80
Lassen/Morgan Summit	77
Lassen/Jonesville	70
Plumas/Bucks Lake and Big Creek	100
Plumas/Gold Lake	10
Plumas/La Porte	72
Tahoe/Bassets	82
Tahoe/Little Truckee Summit	138
Tahoe/China Wall	50
Sequoia/Big Meadow, Quail Flat, Cherry Gap, and Upper Woodward	30
Sequoia/Quaking Aspen, Holby, and Sugarloaf	100
Sequoia/Kern Plateau Westside and Eastside	85
Total	**1,342**

Notes:

OSV Program trailheads which share facilities with sno-parks (Eldorado NF, Stanislaus, NF, and Sierra NF) or trailheads which access OSV Program groomed trails but are not maintained through the OSV Program (Inyo NF) would be plowed and remain accessible.

Source: CDPR, OHMVR Division, 2010

While trailhead parking areas would no longer be plowed, the state highways adjacent to many of these trailheads would continue to be plowed by Caltrans, and therefore trailheads could continue to be used as access points to wilderness areas (e.g., Ashpan and Morgan Summit on Lassen NF). Trailheads which occur at sno-parks (Eldorado NF, Stanislaus NF, and Sierra NF) would continue to be plowed, and wilderness incursions happening from these access points could continue (see Land Use, Table 3-3). Swain Mountain (Lassen NF) access is a local road plowed by the county road department outside of the OSV Program, so the wilderness areas accessed from this trailhead could continue to be accessed. Kern Plateau Eastside trailhead (Sequoia NF) gets low snowfall and rarely needs plowing. Therefore wilderness incursions occurring from this access point would be largely unaffected by discontinued snow removal service. Local county and forest roads accessing the Deer Mountain (Klamath NF), Pilgrim Creek (Shasta-Trinity NF), and Bucks Lake (Plumas NF) would no longer be plowed by the OSV Program under this alternative, and therefore wilderness trespass originating from these areas (Land Use, Table 3-3) could be substantially reduced or eliminated.

Under the No Project Alternative, a substantial drop in OSV use in the Project Area would likely reduce the number of OSV trespass incidents from 2010 baseline levels. At 2010 baseline levels, the project impact of OSV trespass on wilderness, private property, and other administrative closure areas is considered less than significant, so this alternative would further reduce a less than significant impact. Without the OSV Program facilitating OSV recreation, the 4% average annual increase would not be realized. Therefore, the number of future OSV trespass incidents would likely be reduced by the No Project Alternative.

<u>Air Quality, Energy, and Greenhouse Gases</u>. With the OSV Program equipment not used and visitor use cut by two-thirds, there would be a corresponding decrease in air quality emissions from vehicle exhaust, less consumption of energy resources by reduced fuel use, and reduced GHG emissions. Under the No Project Alternative, the Project's less than significant impacts to air quality, energy use, and GHG would be further reduced.

<u>Noise</u>. With the OSV Program equipment not used and visitor use cut by two-thirds, there would be a corresponding decrease in noise from the vehicle engines. Under the No Project Alternative, the Project's less than significant noise impact would be further reduced.

<u>Biological Resources</u>. The potential for biological effects as described in Biology, Section 5.3, would be reduced by the No Project Alternative in proportion to the reduction in OSV use in the trail system area.

The USFS would continue to implement its management actions for northern spotted owl and northern goshawk which mitigates OSV impact on these raptors. The Project's less than significant impact on northern spotted owl and northern goshawk would be further reduced by less OSV use in the Project Area under the No Project Alternative.

The USFS would continue monitoring for California wolverine which is not known to occur in the Project Area. Management actions would continue to be unspecified unless wolverine presence is determined. With reduced OSV use in the Project Area, there is less potential for impact to the California wolverine if presence occurs. The Project's less than significant impact on California wolverine would be further reduced under the No Project Alternative.

Sierra Nevada red fox is known to occur in the Project Area and could be adversely affected by OSV use. USFS does not currently have specific management actions governing Sierra Nevada red fox but is undertaking new studies to determine its level of presence in the Project Area. Under the No Project Alternative, the USFS would still continue its evaluation of the Sierra Nevada red fox and implement new management actions as deemed appropriate. OSV use under the No Project Alternative would be reduced and the potential impact on the Sierra Nevada red fox would be reduced to below existing 2010 baseline levels. With USFS management actions in place the project impact on red fox would be less than significant. Therefore, under the No Project Alternative, the potential impact to Sierra Nevada red fox is less than significant.

The USFS would continue its management actions for special-status plant species. The CNPS 1B, CNPS 2, and FSS species not already monitored by USFS for OSV impacts during low-snow conditions could continue to be impacted by OSV activity. Reduced OSV use under the No Project Alternative reduces the potential for impacts to occur to these plant species. Project mitigation to protect special-status plant species through inventory, monitoring for OSV damage, and implementation of protective measures would not occur under the No Project Alternative.

Therefore, under the No Project Alternative, the potential impact to these plant species would be less than 2010 project baseline conditions, but the potential impact is significant given no management actions are in place to protect these plant species.

Sensitive aquatic resources are not known to be impacted by OSV use facilitated by the OSV Program. Under the No Project Alternative, OSV use would be reduced by one-half to two-thirds further reducing the potential for impact to aquatic resources. Since the potential impact to aquatic resources would be likely limited to occasional incidents with less OSV use, the potential impact under the No Project Alternative is considered less than significant.

Hydrology and Water Quality. The No Project Alternative would eliminate 5,000 hours of annual snowcat operation in the Project Area and reduce OSV use by up to two-thirds resulting in less vehicle exhaust and fewer VOC emissions deposited on the snow pack. The low potential for soil compaction and soil erosion associated with the Project would be further reduced. The lack of restroom service could lead to water quality impacts from human waste deposited on the surface of the snow rather than into sanitary facilities. The Project's impact on hydrology and water quality is less than significant. Under the No Project Alternative, the impact on hydrology and water quality would be less than 2010 project baseline conditions and is therefore less than significant.

Recreation. As noted in Recreation Table 8-2, the OSV Program grooms 1,761 miles of the total 1,851 miles of groomed trail available for motorized recreation in the State of California. Only Eldorado, Stanislaus, and Inyo National Forests have trails groomed with non-state funds. By eliminating state funded trail grooming, the No Project Alternative would eliminate 95% of the groomed trail recreation opportunity in the state. OSV use and non-motorized use could continue in these areas, but given that plowed access would not be provided and trails not groomed, the number of visitors to the sites would be reduced by up to two-thirds. One-third of the survey respondents indicated that they would continue to use the trails if ungroomed. A smaller group (up to 5%) indicated that their use of the trails would increase if trails were not groomed.

As shown in Table 9-1, without plowing, 27 trailheads leading to 1,342 miles of trails (76% of OSV Program groomed trails) would no longer be accessible. The remaining 7 trailheads which double as sno-parks (Eldorado NF, Stanislaus NF, and Sierra NF) would still be accessible. The trailheads at Mammoth Lakes which are not state funded under the OSV Program would also continue to be accessible. OSV use on the trail systems accessed from these 27 unplowed trailheads would be dramatically reduced but not necessarily eliminated. The potentially significant impact of inadequate parking leading to unsafe parking conditions would not necessarily be reduced or eliminated as an unknown number of OSV recreationists would continue to access the trail systems where possible. Although plowed parking would not be available, visitors with vehicles that can handle the road conditions could drive as far as they could go and then park on the side of the road and unload the snowmobiles and begin riding from that point, which could lead to unsafe conditions. Thus, under the No Project Alternative, the potential for lack of adequate parking to adversely impact public safety remains a significant impact.

Patrols of the trail system areas by LEOs and FPOs are provided by each national forest. These patrols would continue under the No Project Alternative. Access to the area from unplowed roads and patrolling the trail system from ungroomed trails would make patrolling more difficult.

Search and rescue operations could also be slowed by unplowed and ungroomed conditions. This would be a potentially significant impact of the No Project Alternative.

At 2010 project baseline OSV levels, the potential for conflicts between motorized and non-motorized use on the trail systems was determined to be less than significant. The increase in OSV use over the 10-year program period was determined to be potentially significant and required could require increased law enforcement. Under the No Project Alternative, OSV use in the Project Area would be reduced by up to two-thirds and likely result in a reduced number of user conflicts. Thus, the less than significant 2010 baseline impact would be further reduced.

Under the No Project Alternative, the overall growth projected by the OSV Program would not be realized. Growth related impacts, such as increased motorized use conflicts, would not occur. Without the projected increase in OSV use levels, the potential need for increased law enforcement patrols would likely not occur. Thus the future demand for increased law enforcement to address recreation use conflicts and safety issues would be less than significant.

Under the No Project Alternative, restroom service and garbage collection at many of the trailheads would be discontinued. This could result in trash and sanitation issues at the trailheads or along the trail routes.

9.3 FUNDING OF RESTRICTED RIDING AREAS ONLY

Under the Funding Restricting Riding Areas Only Alternative, the OHMVR Division would only fund trail grooming in areas where OSV use is restricted to designated routes by the land managers; no grooming would occur where off-trail riding is permissible. At least initially, this alternative would eliminate grooming at 24 of the 26 trail systems. Grooming would continue on two trails systems in the Giant Sequoia National Monument (Big Meadow/Quail Flat and Quaking Aspen/Sugarloaf) where off-trail riding is prohibited. Grooming could be expanded to other locations where the land manager has enacted riding restrictions. With only the trails in the Giant Sequoia National Monument groomed, this alternative would reduce the trail mileage groomed under the OSV Program from 1,761 to 130 miles.

The OSV Program would also only fund access road and trailhead plowing and services at those areas with trail grooming. Thus, the OSV program would only fund plowing for 0.8 miles of County Road 9 (serving Sugarloaf), in addition to parking lot plowing, restroom servicing, and warming hut maintenance for the seven trailheads serving these two trail systems (Big Meadow, Quail Flat, Upper Woodward, Cherry Gap, Quaking Aspen, Holby, and Sugarloaf). Direct access to seven trailheads plowed by Caltrans at the shared trailhead/sno-parks (Project Description, Table 2-6) would continue unaffected. This would preserve access to six of the 24 ungroomed trail systems under this project alternative. Direct access to 18 of the 24 ungroomed trail systems, provided by 20 trailheads currently plowed by the OSV Program, would no longer be plowed.

It is possible that funding from national forests and/or private sources, along with volunteer efforts, could be generated to preserve limited grooming in some trail locations. Given the extensive effort and funding required to maintain the groomed trails at current levels, however, it is assumed the great majority of trails would remain ungroomed. Thus, despite the potential for some of the trailheads to remain plowed and for some limited grooming from non-OSV program sources, visitor use of the trail systems no longer groomed via the OSV Program would likely drop by half and as much as two-thirds based on the visitor trailhead survey.

Land Use Plans and Policies. Similar to the No Project Alternative, the potential for inadvertent trespass into protected wilderness areas, closure areas, and private property at the 24 trail systems no longer groomed as part of the OSV Program would be reduced somewhat in proportion to the drop in OSV use. As discussed under that alternative, while most trailhead parking areas would no longer be plowed, the state highways adjacent to many of these trailheads would continue to be plowed by Caltrans. Ungroomed trail systems and parking along the highways could continue to provide access to wilderness and other closed areas (e.g., Ashpan and Morgan Summit on Lassen NF). Trailheads that occur at sno-parks (Eldorado NF, Stanislaus NF, and Sierra NF) would continue to be plowed, and wilderness incursions happening from these access points could continue (see Land Use, Table 3-3). Since County Road A-21 would continue to be plowed by the county road department outside of the OSV Program, the wilderness area accessed from the Swain Mountain (Lassen NF) trailhead could continue to be accessed. Kern Plateau Eastside trailhead (Sequoia NF) gets low snowfall and rarely needs plowing. Therefore access to the ungroomed trail system from this access point would be largely unaffected by discontinued snow removal service. Local county and forest roads accessing the Deer Mountain (Klamath NF), Pilgrim Creek (Shasta-Trinity NF), and Bucks Lake (Plumas NF) trail systems would no longer be plowed by the OSV Program under this alternative, and therefore wilderness trespass originating from these areas (Land Use, Table 3-3) could be substantially reduced or eliminated.

Since some ungroomed trail systems would remain accessible and used by OSVs, without groomed trails to demarcate authorized routes, and if national forests decrease in patrols on the ungroomed trails, it is assumed that inadvertent trespass into closed areas would increase in some areas. Furthermore, trespass in known hot spots typically occurs as a willful violation of OSV boundaries, and OSV trespass occurs independent of the groomed trail system (see Land Use Table 3-2). Thus, eliminating state funding of groomed trails where off-trail riding is permitted by the land manager would not necessarily prevent OSV users intent on trespass from entering closed areas. Trespass into closed areas from the 24 trail systems no longer groomed would therefore likely be reduced but not eliminated due to overall reductions in OSV use.

OSV riders who prefer groomed trails would be redirected away from the 24 trail locations no longer groomed toward the remaining two groomed trail systems on the Giant Sequoia National Monument. As a result, annual OSV use in the Giant Sequoia National Monument could be dramatically increased and lead to increased OSV trespass into closed areas. The Big Meadow/Quail Flat and Quaking Aspen/Sugarloaf trails in the monument are two of the lesser used trails in the OSV Program groomed trail system (see Sequoia National Forest in Table 2-8). This redirection of OSV riders would likely create a need for increased law enforcement patrols and public outreach to enforce trail riding restrictions. Mitigation Measure LU-1 would need to be implemented to ensure incursions would remain at a less than significant level.

The Winter Trailhead Survey (Appendix A, Table 5), found the average one-way trip distance of OSV recreationists to be about 100 miles, with many survey respondents coming from Northern California population centers such as Stockton, Sacramento, Chico, and the San Francisco Bay Area. Given that the distance of these two trail systems from the point of origin of many of the OSV recreationists is well over 100 miles, it is assumed that a great many OSV recreationists would not travel to Giant Sequoia National Monument. They may attempt to access ungroomed trail systems closer to home, or they may simply curtail OSV recreation until closer groomed, accessible trail systems become available.

Air Quality and Noise. OSV use would continue at the non-groomed trail systems, but at reduced levels similar to the No Project alternative. Exhaust emissions and noise from OSV use would be reduced in proportion to the drop in OSV use. OSV ridership in the Giant Sequoia National Monument may increase due to the lack of other available groomed trail sites. Those trail systems would likely require somewhat increased grooming, as discussed in Section 8.3.3.1. This would result in increased air quality and noise emissions. The noise increases would be confined to the established trail route, which is based on an existing road network. The increased air emissions from the OSVs and grooming equipment would still be less when compared to overall increases expected under the proposed Project.

Biology. The likely drop in OSV use at the 24 non-groomed trail locations under this alternative would likely reduce the potential impacts to special-status plants and wildlife species similar to the No Project alternative. Biological monitoring required by the OHMVR Division as part of the OSV Program would not occur at these locations. OSV ridership in the Giant Sequoia National Monument would likely increase. OSV use in the Giant Sequoia National Monument is limited to designated routes which occur over existing paved roads and gravel-base or dirt roads used in summer as OHV trails and for other motorized access. As such, there would be little to no potential for trampling of vegetation and sensitive aquatic habitats by OSV use. Wildlife impacts would not be significantly increased by the increase in OSV ridership given the restriction on OSV use to an established road network. This alternative could require increased monitoring and law enforcement patrols (see Mitigation Measure LU-1) to enforce riding restrictions and ensure the protection of biological resources.

Hydrology and Water Quality. Under this alternative, OSV use would continue at the 24 trail systems no longer groomed but likely at a reduced level. The potential impacts to water quality from erosion or vehicle exhaust on the snow pack would be less than the proposed Project and similar to the No Project alternative. OSV visitor use in the Giant Sequoia National Monument would likely increase. Use would be restricted to a trail system over an existing road network, and therefore there would be little potential for soil erosion impacts. The amount of exhaust emissions on the snow pack would be increased in proportion to the increase in OSV use of the trails. The nine trailheads (7 program and 2 non-program) serving Big Meadow/Quail Flat and Quaking Aspen/Sugarloaf trails generate 87 passenger vehicles on a maximum day (Table 8-3) which corresponds to roughly 8,000 seasonal OSV use days. The increase in ridership at the monument is unlikely to reach Yellowstone levels which at almost 48,000 OSV use days (Section 6.3.3) was determined to have a less than significant impact on water quality.

Recreation. This alternative would eliminate all but 130 miles of the 1,761 miles of groomed trail in the OSV Program. As a point of OHMVR Division policy, expansion of the state-funded groomed trail system in the future would be limited to those areas where off-trail riding is prohibited. This alternative would result in the loss of groomed trail access similar to the No Project Alternative. Those riders who spend the majority of their time riding off-trail in ungroomed conditions are least likely to be affected by this alternative, although a majority of trailheads would no longer be plowed or maintained. Ungroomed trails could slow an emergency response to a search and rescue call. Beginning riders and those who prefer groomed trails would have their opportunities for public trail recreation drastically reduced from 24 trail systems statewide to two trail systems only, both located on the Giant Sequoia National Monument and thus far away from many OSV recreationists. Likewise, non-motorized users of the groomed trail system would also have reduced opportunities. The recreation impacts at the 24 trail system locations no longer groomed would be similar to the No Project Alternative. The recreation impacts at the two remaining trail systems, Big Meadow/Quail Flat and Quaking Aspen/Sugarloaf, would likely be immediately increased due to an increase in OSV ridership similar to those impacts described under the 10-year program growth (Section 8.3.3).

9.4 REDIRECTION OF GROOMING FUNDS

The 2002 BCP allocates up to one million dollars from the OHV Trust Fund for winter trail maintenance, including grooming, plowing, and restroom service, that directly supports OHV winter recreation. None of the OSV Program funds are used to provide law enforcement, public education, or biotic resource inventories and monitoring, all of which are identified in the EIR analysis as needed mitigation and could require additional funding (Land Use Section 3.3.4, Biology Section 5.3.4, and Recreation Section 8.3.4). These three responsibilities are primarily funded and staffed as needed by the USFS (Project Description, Section 2.5) with some periodic funding provided by the OHV Trust Fund through the Grants Program. Under the Redirection of Grooming Funds Alternative, a portion of funds allocated by the 2002 BCP for grooming (the primary funded activity of the OSV Program) would be redirected to fund the needed law enforcement, public outreach, and biotic resource monitoring measures specified in the EIR while keeping total funding for the OSV Program under the 2002 BCP million dollar cap. This alternative would have the benefit of securing funds for EIR mitigation within the 2002 BCP budget cap. However, given that resource monitoring, public education, and law enforcement activities are not specific activities authorized for funding under the BCP, an amendment would be required for the OSV Program to fund these activities through the BCP funding allocation. Under this project alternative, grooming frequency throughout the Project Area would be reduced to free up funding for law enforcement and resource monitoring. Plowing would remain unchanged in order to preserve access to all trailheads. This alternative would not necessarily stop grooming but would substantially reduce the frequency of grooming, leaving trail conditions rough. These conditions could result in reduced OSV use on the project trails throughout the Project Area.

<u>Land Use Plans and Policies</u>. Under this alternative OSV use would continue but likely be reduced. Incidents of OSV trespass may be somewhat reduced by few numbers of riders on the trail system. However, given that trespass is also known to occur outside of the groomed trail systems of the Project Area (see Land Use Plans and Policies, Section 3.3.3) it is likely that trespass will still occur even with rougher trail conditions. Law enforcement measures and public outreach as required for the Project would be provided for under this alternative without increased funding through a modified BCP to allow law enforcement expenditures. The impact of this alternative would be similar to the Project. Mitigation Measure LU-1 would be implemented, thus the impact from OSV trespass would remain less than significant.

<u>Air Quality and Noise</u>. Hours of grooming equipment operation would be reduced by this alternative resulting in reduced air quality emissions and noise throughout the Project Area. Reduced grooming could result in reduced OSV use of the trail systems. Based on the Winter Trailhead Visitor Survey (Appendix A), half of the respondents indicated that they were less likely to use the trail system and trailhead if trail grooming was not provided. A reduction in trail grooming rather than elimination of trail grooming may not affect overall OSV use levels. To the degree that OSV use is reduced, this project alternative would result in less air quality emissions. Ambient noise levels at trail sites would also be somewhat reduced by this alternative to the degree that OSV use is reduced. The project noise impact is less than significant and therefore the noise impact under this alternative would remain less than significant.

Biology. Since project grooming would not result in direct biological impacts, reducing or eliminating grooming would not reduce biological effects of the project. Reduction in OSV use that may occur as a result of reduced grooming could reduce potential adverse biological effects similar to the No Project Alternative described above. Under this alternative, a portion of grooming funds would be allocated for biotic resource inventories, monitoring, and implementation of management actions required in Measures BIO-1 through BIO-5 once the BCP was amended. The effects of this alternative on biological resources would be the same as for the Project or slightly less to the degree that OSV recreation is reduced by less frequent grooming of the trails. The impact of this alternative on biological resources would be less than significant

Hydrology. This alternative would slightly reduce VOC emissions on the snowpack due to reduced grooming equipment operations and a presumed reduction in OSV use. The impact would remain less than significant. The alternative may slightly reduce the potential for soil erosion by reducing OSV use and the potential for OSVs to cross bare soil. The project level impact is not significant, and therefore this alternative would further reduce a less than significant impact.

Recreation. Redirection of funds from grooming would create less favorable riding conditions and would likely result in less OSV use by riders who spend the majority of time on the groomed trail system (Appendix A). Rough trail conditions create an uneven snow surface, which could lead to increased safety hazards for trail riders. Ungroomed trails can slow an emergency response to a search and rescue call. Less OSV use would reduce the demand for parking. For trailheads experiencing excessive parking demand, this alternative would reduce the demand and relieve overcrowded conditions. Safety impacts associated with crowded parking conditions of the Project were determined to be less than significant with mitigation over the 10-year project life. With reduced parking demand under this alternative, the less than significant public safety impacts would be somewhat diminished.

9.5 ENVIRONMENTALLY SUPERIOR ALTERNATIVE

CEQA requires that the EIR analysis of project alternatives identify an "environmentally superior" alternative. If the environmentally superior alternative is the "No Project" alternative, the EIR shall also identify an environmentally superior alternative from among the other alternatives. Funding groomed trails in restricted riding areas only would limit OSV use associated with the OSV Program to groomed trails, which are established travel routes with a paved or dirt and gravel road base. This substantially reduces the potential for impact to biological resources and inadvertent wilderness trespass associated with the OSV Program as a whole. Off-trail OSV use would continue in national forests but likely at reduced levels and therefore environmental effects from OSV use in these areas would likely be reduced. For these reasons, Funding Restricted Riding Areas Only is considered the environmentally superior alternative that can partially meet the project objectives.

10.0 CEQA REQUIRED ASSESSMENTS

10.1 POTENTIALLY UNAVOIDABLE SIGNIFICANT IMPACTS

There are no significant unavoidable impacts associated with the OSV Program, Program Years 2010-2020. Potentially significant impacts of the OSV Program, are identified in Chapters 3.0 through 8.0 of this EIR along with mitigation measures that would reduce or avoid these impacts. All project impacts can be reduced to a less than significant level with mitigation.

10.2 IRREVERSIBLE ENVIRONMENTAL CHANGES

CEQA requires that an EIR assess whether a Project will result in significant irreversible changes in the environment. The CEQA Guidelines describe three distinct categories of irreversible changes that should be considered, as further detailed below.

10.2.1 Changes in Land Use which Commit Future Generations

The Project would not involve any changes in land use, or permanent changes in the character of the Project Area. All project sites occur in national forests, in areas open to OHV vehicle recreation. No new facilities are proposed for construction. The direct effects of compaction and moving of snow involved in plowing and grooming activities would be a seasonal temporary physical change in the environment. The increase in winter recreational access facilitated by the Project would not be an irreversible change.

10.2.2 Irreversible Damage from Environmental Accidents

The proposed Project would not involve the use or transport of hazardous materials in substantial quantities, nor any other potential for environmental accidents. Some OSV users may refuel their equipment at trailhead parking lots, which may result in occasional spills of small amounts of fuel. Such occurrences would be infrequent and any resulting damage would be minor and not irreversible.

10.2.3 Consumption of Natural Resources

Examples of consumption of non-renewable resources include increased energy consumption, conversion of agricultural lands to urban uses, and loss of access to mining reserves. The Project would not involve the conversion of agricultural land or the loss of access to important mineral reserves. The proposed Project would irretrievably commit non-renewable fossil fuel resources by the State of California to provide statewide winter trail recreation in national forests. Winter trail recreation itself requires consumption of fossil fuel energy for the transport of trail visitors to the Project Area and for the OSV recreation occurring on the trails. This is addressed in Air Quality, Energy, and Greenhouse Gases, Section 4.3.3. Through the Off-Highway Motor Vehicle Recreation Act of 2003, the Legislature has recognized the popularity of OHV recreation and charged the OHMVR Division with supporting both motorized recreation and motorized off-highway access to nonmotorized recreation. Considering this statutory mandate to support OHV recreation, the Project would not result in energy consumption that is inefficient, wasteful, or unnecessary as identified in CEQA Appendix F. Therefore, the project effect on energy resources is considered less than significant.

10.3 GROWTH INDUCEMENT

A project is considered to be growth-inducing if it fosters economic or population growth beyond the boundaries of the project site by, for example, the extension of urban services or transportation infrastructure to an underserved area, or by the removal of major constraints to development. At 2010 baseline conditions, the proposed Project involves funding of plowing, trail grooming, and trailhead maintenance services which already occur as part of the established OSV Program. The Project does not involve the provision of new infrastructure nor remove any existing constraints to development. The recreational opportunities represent a continuation of historic and existing operations and would not in themselves attract new residents or employees or provide infrastructure needed to support developmental growth. Thus, project operations at 2010 baseline levels are not growth inducing.

The OSV Program direct operations could expand over the next 10 years to include expanded trailhead parking, increased grooming operations at existing trail sites, and new trail system locations. Opening the Four Trees trailhead in the Bucks Lake area in Plumas National Forest. The trailhead already exists but is seasonally closed during winter months. Plowing the access road and trailhead parking lot would allow Bucks Lake to be accessed from the west in addition to the current access points from the east (Map 6A). Opening this trailhead would facilitate greater access to Bucks Lake and could increase winter visitor use of the Bucks Lake trail system by providing 20 additional parking spaces needed for the trail system visitors. This could generate an increase of 920 passenger vehicles and 1,840 OSVs per season. Likewise, expanding the China Wall trailhead to provide 30 additional spaces for vehicles could generate an increase of 1,380 passenger vehicles and 2,760 OSVs per season. Opening the Four Trees trailhead and expanding the China Wall trailhead for winter use would not introduce new infrastructure and would not facilitate new developmental growth.

Growth in grooming equipment operations by up to 500 hours at existing trail sites may occur over the 10-year program. The grooming program operates close to its maximum need based on typical snow conditions. An increase in system wide grooming operations by 500 hours amounts to two days of extra grooming at each trail site during a season. The increased equipment operation does not introduce new infrastructure and is not growth inducing.

The OHMVR Division has identified three new trail site locations for possible future inclusion in the OSV Program. A trailhead currently exists at one of these locations (Lake Davis); new trailheads could be developed at the other two locations (State Route 4 and Bass Lake) to include vehicle parking and restrooms. Plowed access is already provided at Lake Davis and Bass Lake. New plowed access would be required for State Route 4. Expanding the OSV Program to new locations would not facilitate developmental growth and land use changes in the surrounding area. However, establishing new trail systems would increase recreation opportunity and increase the number of wintertime visitors to the project area. While not directly growth inducing, this could have an indirect economic benefit to local communities.

The Project would indirectly support OSV use of the groomed trail systems. Historical growth rates in the number of OSV registered with the California DMV suggest that OSV use throughout the Project Area could continue to increase by 48% over the 10-year period of the Project. Annual OSV use of groomed trails in the Project Area could increase from 159,000 (Project Description, Table 2-8) to 235,000. This increased use would be dispersed throughout the 26 OSV Program trail systems and throughout the 14-week winter season (mid-December through March). Developmental growth such as new businesses or residences is unlikely to develop as a result of increased OSV use on project trails given the dispersed nature of the visitor increase and the short-term seasonal nature of the OSV visitors to the Project Area.

10.4 CUMULATIVE IMPACTS

Section 15130(a) of the CEQA Guidelines requires a discussion of the cumulative impacts of a project "when the project's incremental effect is cumulatively considerable." Cumulatively considerable, as defined in Section 15065(a)(3) "means that the incremental effects of an individual project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects."

CEQA Guidelines Section 15355 defines cumulative impact as "two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts." The Guidelines further state that "the cumulative impact from several projects is the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonable foreseeable probable future projects." Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time.

The Project Area comprises 26 trail systems and 34 trailheads in 11 national forests. Other activities permissible within the national forests such as timber harvesting, mining, recreation, and grazing could contribute toward cumulative effects of the Project. All activities occurring within the forest are managed in accordance with LRMP policies adopted for each national forest. Many of the activities occurring in national forests do not overlap with the winter recreation activity proposed by the OSV Program; they occur in geographically separate areas of the forest and occur in different seasons.

Each national forest maintains a Schedule of Proposed Actions (SOPA) which provides a public listing of proposals that will begin or are undergoing environmental analysis and documentation. The SOPA includes proposals whose decisions are expected to be documented in a Decision Memo, Decision Notice, or Record of Decision, pursuant to NEPA and agency direction. A list of projects from the current SOPA report of each national forest that could physically affect the environment and contribute to cumulative project impacts is presented in Appendix G. The majority of actions listed fall into the following categories: timber management (commercial thinning); vegetation management and habitat enhancements; fuel reductions (prescribed burns, pile burning, and fuel breaks); road and trail management (construction, decommissioning, re-routes, repairs); erosion control at stream crossings, culverts, and road cuts; recreation facilities (day use areas, campgrounds, trailhead improvements, OHV special events); utility line maintenance; and mining operations (gravel and gold).

Cumulative impact analyses are provided for each environmental discipline in their respective EIR chapters. The EIR has determined that the OSV Program, Program Years 2010-2020 project would not result in any incremental effect that is cumulatively significant when considered with other projects.

10.5 IMPACTS FOUND TO BE NOT SIGNIFICANT

The following environmental topics were determined to be not significant and are therefore not discussed in detail in this EIR.

10.5.1 Aesthetics

Visual Character. Trail grooming, road plowing, and routine maintenance activities at the Project sites, and off-trail OSV use indirectly facilitated by the Project, would result in a negligible and temporary change in the visual character of the Project Area as compared to undisturbed snow. Plowing would occur only within the existing footprint of paved access roads and parking lots. All groomed trails are existing native surface roads designated for wintertime OSV use in the respective forest plans. Minor brush clearing would occur only if needed within the existing trail alignments. Groomed trails are not visually prominent within the overall expansive snow-covered visual setting, and are often obscured from view by the landform or vegetation. OSV tracks, even in areas of more concentrated off-trail open area use, are also a negligible and temporary change in visual character as compared to undisturbed snow.

Scenic Vistas. Given the negligible impact on the visual character of the Project sites, no officially designated or protected scenic vistas would be threatened by the Project. Many trails have scenic vista points, but trail grooming would not significantly impact these views.

Several of the highways that provide access to project trailheads are officially designated State Scenic Highways. Additionally, several routes are designated as National Scenic Byways by the U.S. Department of Transportation, Federal Highway Administration or National Forest Byways by the U.S. Department of Agriculture, Forest Service. Table 10-1 shows the State and federally designated scenic highways located near trails and their approximate distance from the project trail system.

Table 10-1. Designated Scenic Highways Located Near Project Trails

Project Trailhead	Route/ Designation	Distance To Project
Klamath NF Deer Mountain trail system	Highway 97/ National Scenic Byway	Majority of trail system occurs within a 4-mile distance from Hwy 97.
Modoc NF Medicine Lake trail system and Doorknob trailhead	SR 139 Emigrant Trail/ National Forest Byway	Trailhead and trail system occurs beyond 10 miles of SR 139.
Shasta-Trinity NF Pilgrim Creek trail system	SR 89/ National Forest Byway	Majority of trail system occurs beyond 5 miles of SR 89.
Lassen NF Ashpan, Bogard, Fredonyer, Morgan Summit, and Swain Mountain snowmobile areas	State Routes 89, 44, and 36/ National Forest Byway	Trailheads are on the scenic byway. Majority of Ashpan and Morgan Summit trails are within 4 miles of SR 89. Bogard, Swain Mountain and Fredonyer trails are dispersed 10 miles from SR 44 and SR 36.
Plumas NF Bucks Lake and La Porte trail systems	SR 70 Feather River/ National Forest Byway	Bucks Lake trail system is 5 miles from SR 70. La Porte trail system is 15 miles from SR 70.
Tahoe NF Bassets trail system	SR 49/ State Scenic Highway,	The trails occur within a 4-mile distance of SR 49.

Table 10-1. Designated Scenic Highways Located Near Project Trails		
Project Trailhead	**Route/ Designation**	**Distance To Project**
	National Forest Byway	
Eldorado NF Silver Bear trail system and Iron Mountain trailhead	State Route (SR) 88 Carson Pass/ State Scenic Highway, National Forest Byway	Trailhead has entrances on SR 88. Majority of trail system occurs within a 4-mile distance from SR 88.
Stanislaus NF Lake Alpine trail system	SR 4 Ebbetts Pass/ State Scenic Highway and National Scenic Byway	Trailheads are on the scenic highway. The trails occur within a 4-mile distance from SR 4.
Inyo NF Mammoth/June Lake trail systems and Shady Rest trailhead	Hwy 395/ State Scenic Highway	Majority of trail systems occur within a 4-mile distance from Hwy 395.
Sierra NF Huntington Lake/Kaiser Pass and Tamarack Ridge trail systems and trailheads	SR 168/ National Forest Byway	Trailheads are on the scenic byway. The trails occur within a 4-mile distance from SR 168.
Sequoia NF Big Meadow/Quail Flat trail system	SR 180 Kings Canyon/ National Forest Byway	Majority of trail system occurs within a 4-mile distance of SR 180.

Source: Caltrans 2009; FHWA 2009

Groomed project trails and open riding areas may be visible from some vantage points along scenic highways. Groomed trails are not visually prominent within the overall expansive snow-covered visual setting, and are often obscured from view by the landform or vegetation. OSV tracks, even in areas of more concentrated off-trail open area use, are also a negligible and temporary change in visual character as compared to undisturbed snow. No rock outcroppings or historic buildings would be threatened by the Project. Additionally, project activities are not within the scope of activities controlled by State Scenic Highway corridor protection programs.

Light and Glare**.** There is currently no lighting at the project trailhead parking lots or trails and no lighting is proposed by the Project. Snow plowing and grooming typically occur at night, and the vehicles are operated with lights. Vehicle lights illuminate the immediate path of the vehicle and do not create ambient lighting conditions. OSVs are equipped with headlamps and trails are accessible at night, and an estimated 29 percent of OSV use occurs at night (see Project Description, Table 2-7). Light from OSVs ridden at night could be visible from longer distances in clearings, but is mostly hidden by trees and landforms.

The direct and indirect impacts of the project related to aesthetics would be less than significant.

10.5.2 Agriculture and Forest Resources

The Project is located on national forest lands in alpine mountainous areas. There is no farmland within or near the Project Area. Neither the project sites nor the surrounding lands contain any farmland, any lands under Williamson Act contracts, or any Prime Farmland, Unique Farmland, or Farmland of Statewide Importance, as defined by the Farmland Mapping and Monitoring Program. The Project would have no impact on agricultural resources. The Project Area occurs within national forests. The Project does not involve removal of timber resources or loss in forest land or conversion of forest land to non-forest use.

10.5.3 Cultural Resources

Sensitive cultural resources sites are known to exist in proximity to the Project in the Modoc, Shasta-Trimity, and Sequoia National Forests. Certain portions of the Project occur in areas, such as the Medicine Lake Highlands area of Modoc National Forest, which are sacred to Native American tribes. Additionally, there may be previously undiscovered historical, archaeological, or paleontological resources, or human remains, within or near the project sites. However, trail grooming would occur only if and when there is a minimum of 12 inches of snow cover (and in certain national forests, a minimum of 18 or 24 inches) and would not disturb the underlying soils. The locations of known cultural resources sites are considered by the national forests in their designation of OSV trails and open riding areas. The USFS has determined that the OSV Program activities would not have an adverse affect upon cultural resources. No cultural resources are known by the USFS to be impacted by OSV use of Program trails and associated riding areas. The Project continues OSV use in existing areas. No new cultural resource area would be exposed to OSV use. The Project would have a less than significant impact on cultural resources.

10.5.4 Geology and Soils

<u>Seismicity and Landslides</u>. The Project activities comprise maintenance of existing winter trail facilities through snow removal on paved access roads and trailhead parking areas, grooming along established trail routes, and restroom cleaning and garbage collection. Project activities support recreational use of the winter trail system. Trail sites within the Project Area are not located in known earthquake fault rupture zones. Many trails within the Project Area could be subject to strong seismic shaking from a seismic event on a regional fault line. Seismic related ground failure is unlikely given the nature of the underlying soil types present throughout the Project Area. Project trails could have segments subject to falling rock and landslides. The project trails designated for grooming have been in use for winter recreation for many years. Trails are maintained during the summer months for OHV use and additional trail maintenance occurs to remove possible obstructions from down trees or rock debris in order to protect the safety of trail groomers and OSV users. Trail use is limited to the winter season when soil is covered with snow and would not impact soils or contribute to or be impacted by landslides. No new structures are proposed which would be subject to seismic shaking or expose people to new risks from seismic shaking.

<u>Soil Erosion</u>. See Hydrology, Section 6.3.2.

<u>Unstable Geologic Unit or Soil</u>. The Project does not involve soil disturbance of any type or new construction. Trail grooming and subsequent OSV use of trails would not create unstable geologic conditions.

<u>Expansive Soil</u>. The Project involves snow plowing on paved roads, snow grooming on trails for OSV use, and facility maintenance such as servicing restrooms and warming huts. The Project does not involve any new construction. Expansive soils, if present, in the Project Area would be covered in snow and undisturbed by the Project.

Soils Incompatible for Septic Use. No septic tanks or wastewater service systems are proposed as part of the Project.

10.5.5 Hazards and Hazardous Materials

Emergency Plans. The Project would not affect implementation of or physically interfere with any adopted emergency response or evacuation plan. Groomed trails facilitate access by forest rangers, fire fighters and others in search and rescue operations and evacuations. Project impacts on transportation are discussed in section 10.5.9 Transportation below.

Wildland Fire. Project plowing, grooming and maintenance activities, and any additional OSV use facilitated by the Project, would occur in winter with snow covering the ground, when wildland fires are highly unlikely.

Flooding. The Project does not involve the development of housing or any structures within a 100-year flood hazard area. Portions of project trails traverse areas subject to inundation during large storm events, and OSV users may access off-trail open areas subject to inundation. However, OSV use would occur during winter when flooding is less likely and is not likely to occur during periods of heavy rainfall or snowmelt, and potential inundation.

Seiche and Tsunami. The resonant oscillation of water in an enclosed water body, often generated by an earthquake, is a seiche. A tsunami is a series of waves created when a body of water is rapidly displaced on a massive scale. Earthquakes, landslides, and snow avalanches have the potential to generate tsunamis in larger water bodies in the Project Area. The occurrence of a landslide or avalanche, or of an earthquake producing the necessary frequency of oscillation that results in seiche, within a water body of sufficient size at a time when OSV users are present is remote. There would be no impact on the Project from seiches or tsunamis.

Avalanches. Locations of identified foreseeable significant avalanche hazard are considered by the USFS in the designation of OSV trails and OSV open riding areas. The increase in OSV use, and range of access indirectly facilitated by the Project, may indirectly expose a greater number of recreationists to avalanche hazard, which is a voluntary risk inherent in the sport.

Hazardous Materials. The routine transport and use of hazardous materials involved in the Project would be limited to the small quantities of operating fuel in the fuel tanks of the snow plows and grooming vehicles, and common janitorial supplies used in the cleaning of vault toilets. Snowcats and snowplows would be refueled at existing fueling stations and not at the project site, and thus would not pose a risk of fuel spills. The Project may facilitate an increase in OSV use, and some of the additional OSV users may refuel their snowmobiles in the trailhead parking lots, potentially resulting in occasional small fuel spills, but such spills would be in amounts that would not pose a significant hazard to the public or the environment.

The Project would not involve the disposal of hazardous materials, emit hazardous emissions, or involve the handling of hazardous materials within one-quarter mile of an existing or proposed school.

There are no sites identified on the Cortese list or the Department of Toxic Substance Control's (DTSC) Hazardous Waste and Substances Site List within the Project Area (DTSC 2008).

Project impacts related to hazards and hazardous materials would be less than significant.

10.5.6 Mineral Resources

The proposed Project involves snow plowing on paved roads and parking areas, grooming snow covered recreation trails, and maintenance of supporting facilities (restrooms, warming huts) in national forests. No soil disturbance would occur. The Project would not result in the loss of availability of known mineral resources of regional or local importance as the Project does not involve the removal of material from the area. Nor does the Project result in the establishment of land uses that would preclude mineral extraction in the event that important mineral resources are considered for removal in the future. Potential deposits would not be covered or modified by the proposed project activities.

10.5.7 Population and Housing

The Project would not involve the construction of new homes or businesses and thus would not directly result in population growth. As explained in Section 10.3 Growth Inducement, the Project would also not indirectly result in additional population or housing. There is no housing and there are no people residing in the Project Area; the Project would not involve the displacement of housing or people. The Project would have no impact on population and housing.

10.5.8 Public Services

Fire Protection. Fire protection in the national forests is provided by USFS staff and the California Department of Forestry and Fire Protection. The Project activities and the indirect increase in OSV use indirectly facilitated by the Project would occur in winter in snow conditions when fire hazard is extremely low. The Project would not directly or indirectly result in an increased risk of fire or in an increased demand for fire protection or need for additional fire protection facilities, equipment, or personnel.

Police. USFS law enforcement officers and forest protection officers provide police service in national forests. These officers enforce trail use and open area access restrictions, as well as providing general law enforcement. The Project would indirectly facilitate increased OSV use levels through 2020 necessitating the need for increased law enforcement personnel. This is further discussed in Recreation, Section 8.3.4.

Schools, Parks, and Other Public Facilities**.** The Project would not directly or indirectly result in an increase in the resident population of the area and thus would not generate any need for new or altered school, park, or other public facilities related to population growth. The USFS, as well as the County, has indicated that the estimated increase in OSV use facilitated by the Project would not generate a need for additional facilities, the construction of which could potentially cause environmental impacts. The Project would have no impact related to schools, parks, and other public facilities.

10.5.9 Transportation

Traffic Circulation and Congestion**.** Project trailheads are accessed directly from state highways, county roads, or USFS roads. The Project would indirectly facilitate increased OSV use through 2020, resulting in a corresponding increase in vehicle trips dispersed over the highways and local roads providing access to project trailheads. Additionally, project-related vehicles would frequently be towing trailers, carrying considerable weight, and thus may travel more slowly.

OSV use occurs in winter throughout a 14-week season (mid-December through March) with heaviest use occurring on weekends and holidays. Therefore, vehicle traffic generated by the Project would not be expected to substantially contribute to weekday peak period congestion. The addition of project traffic to local roads and highways during the peak use periods on winter weekends and holidays may result in some reduction in travel speeds, increased demand for passing to maintain travel speeds, and increased time spent and a greater number of vehicles caught behind slow moving vehicles and left-turning vehicles. However, given the dispersal of vehicle trips over the road network, the Project does not result in traffic congestion or conflict with traffic management plans for state highways or county roads.

Air Traffic**.** The Project would have no impacts related to air traffic.

Design Hazards. The Project does not involve new roads or introduce design features that would create traffic hazards.

Emergency Access**.** The increase in traffic, turning movements into and out of trailhead parking lots, and occasional unauthorized spillover parking along the edges of roads and highways, would not result in a significant impact on emergency access or evacuation.

Public Transit, Bicycle, and Pedestrian Facilities**.** There are no plans, policies, or programs supporting public transit, bicycle, and pedestrian facilities that pertain to the Project. The Project would have no impact with respect to these methods of transportation.

10.5.10 Utilities

Stormwater Drainage. The Project would not involve the expansion of trailhead parking lots or the trail system, and would not result in an increase in the volume of stormwater runoff discharged or any changes in existing stormwater drainage facilities or measures.

Water. No water is supplied at project trailheads. The proposed Project activities would not involve the use of any water. The Project would have no direct or indirect impact on water supply, or on water treatment, conveyance, or distribution facilities.

Wastewater. The increase in OSV use which would occur over the 10-year life of the Project would result in increased sewage waste generated by OSV users and collected at trailhead vault toilets. The collection and disposal of wastewater from vault toilets at trailheads would be funded in part as part of the Project. Wastewater would be pumped from vault toilets and transported to local treatment and disposal facilities. These facilities would be expected to have sufficient remaining capacity to accommodate the minor amount of waste that would be indirectly generated by the Project.

Solid Waste. The estimated increase in OSV use which would occur over the 10-year life of the Project would result in increased solid waste generated by OSV activities and collected at trailhead receptacles. Garbage collection at trailheads would be funded as part of the Project. The collected waste would be disposed of at area landfills and recycling facilities. The capacity through 2020 of each of the transfer stations and recycling facilities, and the remaining permitted capacity of each of the landfills, would be expected to be sufficient to accommodate the minor amount of waste that would be indirectly generated by the Project.

Project impacts on all utilities would be less than significant.

11.0 REFERENCES

11.1 BIBLIOGRAPHY

Ahlborn, G. 2005. American Badger (Taxidea taxus). California Wildlife Habitat Relationships System, California Department of Fish and Game, California Interagency Wildlife Task Group.

American Council of Snowmobile Associations. Sound & Environment. http://www.snowmobilers.org/facts_sound.html. Accessed January 13, 2010.

Arnold, Jeffrey L. and Todd M. Koel. 2006. Effects of Snowmobile Emissions on the Chemistry of Snowmelt Runoff in Yellowstone National Park Final Report. Yellowstone National Park, Wyoming.

Baker, E. and Bithmann, E., 2005. Snowmobiling in the Adirondack Park: Environmental and Social Impacts. St. Lawrence University, Department of Biology.

Barbour, Michael, Todd Keeler-Wolf, and Allan Schoenherr. 2007. Terrestrial Vegetation of California. Berkeley and Los Angeles: University of California Press.

(BAAQMD) Bay Area Air Quality Management District. 2010. California Environmental Quality Act Air Quality Guidelines. June 2010.

Biodiversity Conservation Alliance. 2002. Keep the Medicine Bow WILD (Draft). Retrieved from www.voiceforthewild.org/mbnf/pubs/mb_cit_alt.pdf.

Brander, R. B. 1974. Ecological impacts of off-road recreation vehicles. In: Outdoor recreation research: applying the results. p. 29-35.

Buehler, David A. 2000. Bald Eagle (Haliaeetus leucocephalus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/506. Accessed August 20, 2009.

Bull, Evelyn L. and James R. Duncan. 1993. Great Gray Owl (Strix nebulosa), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/041. Accessed August 21, 2009.

Bunnell, Kevin D., Jerran T. Flinders, and Michael L. Wolfe. 2006. Potential Impacts of Coyotes and Snowmobiles on Lynx Conservation in the Intermountain West. Wildlife Society Bulletin. 34 (3): 828-838.

California Air Resources Board (CARB). 1994. 1994 California State Implementation Plan.

California Air Resources Board (CARB). 2005. California Air Resources Board. Final Statement of Reasons – Regulations to Control Greenhouse Gas Emissions from Motor Vehicles. August 4, 2005. Available online at: http://www.arb.ca.gov/regact/grnhsgas/fsor.pdf

California Air Resources Board (CARB). 2007a. Staff Report: California 1990 Greenhouse Gas Emission Level and 2020 Emission Limit, Public Release Date November 16, 2007.

_____ 2007b. OFFROAD 2007. User’s guide: www.arb.ca.gov/msei/offroad/pubs/ users_guide_b.doc.

California Air Resources Board (CARB). 2008. Climate Change Scoping Plan, A Framework for Change. December 2008.

California Air Resources Board (CARB). 2010a. Area Designation Maps. http://www.arb.ca.gov/ desig/adm/adm.htm. Accessed September 29, 2010.

______2010b. California Greenhouse Gas Inventory for 2000-2008 by Category as Defined in the Scoping Plan. Last Updated: Wednesday May 12, 2010 http://www.arb.ca.gov/cc/inventory/data/data.htm

California Department of Fish and Game (CDFG). 2007. Commonly asked questions about mountain lions. Retrieved from http://www.dfg.ca.gov/news/issues/lion/ lion_faq.html. Accessed December 6, 2009.

______2008. Great Gray Owl Web Site. Interior Timberland Planning, Habitat Conservation Program, Northern Region. Redding, California. Retrieved from https://r1.dfg.ca.gov/portal/itp/WildlifeSpecies/GreatGrayOwl/tabid/616/Default.aspx Accessed August 21, 2009.

California Department of Motor Vehicles (DMV). 2009. Off-Highway Vehicles Currently Registered as of April 30, 2009.

California Department of Parks and Recreation (CDPR). 1998. California Snowmobile User Survey 1997. Prepared by Barry Jones, Winter Recreation Program Coordinator. November 1998.

______1999. California Trail Grooming Operator Certification and Training Handbook. California State Parks, Off-Highway Motor Vehicle Recreation Division. Prepared by Barry Jones, Winter Recreation Program Coordinator, and California Grooming Committee. November 1999.

______2005. California’s Recreation Policy. California State Parks.

______2007. California Snowmobile Trail Grooming. California State Parks, Off-Highway Motor Vehicle Recreation Division. Prepared by Barry Jones, Winter Recreation Program Coordinator and California Grooming Committee. October 2007

______2008. Soil Conservation Standard and Guidelines. California State Parks, Off-Highway Motor Vehicle Recreation Division.

______2009. California Outdoor Recreation Plan 2008. An Element of the California Outdoor Recreation Planning Program. California State Parks.

California Department of Transportation (Caltrans). 1991. Caltrans Technical Analysis Notes. March 1991.

______2008. Scenic Highway Routes: Caltrans Landscape Architecture Program. http://www.dot.ca.gov/hq/LandArch/scenic/cahisys.htm August 27, 2008.

California Department of Toxic Substance Control, 2007. Cortese List on Website http://www.envirostor.dtsc.ca.gov/. Accessed August 24, 2007.

California Energy Commission (CEC). 2007. State Alternative Fuels Plan, Commission Report, CEC-600-2007-011-CMF, December 2007.

California Golden Trout Information Center (CGTIC). 2010. California golden trout. Retrieved from http://www.tucalifornia.org/cgtic/CGTbasics.htm. Accessed February 7, 2010.

California Herps. 2010. Species pages. Retrieved at www.californiaherps.com. Accessed February 9, 2010.

California Native Plant Society (CNPS). 2010. Inventory of Rare and Endangered Plants. http://cnps.web.aplus.net/cgi-bin/inv/inventory.cgi.

California Natural Diversity Database (CNDDB). 2010. Biogeographic Data Branch. California Department of Fish and Game. Version 3.1.

California Regional Water Quality Control Board (RWQCB) Central Valley Region. 2004. Water Quality Control Plan for the Tulare Lake Basin Second Edition. January 2004.

______2007. Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board Central Valley Region (Fourth Edition). The Sacramento River Basin and the San Joaquin River Basin. Sacramento, California. October 2007.

California Regional Water Quality Control Board (RWQCB) Lahontan Region. 2005. Water Quality Control Plan for the Lahontan Region North and South Basins. December 2005.

California Regional Water Quality Control Board (RWQCB) North Coast Region. 2007. Water Quality Control Plan for the North Coast Region. January 2007.

Calflora: Information on California plants for education, research and conservation. (web application). 2008. Berkeley, California: The Calflora Database (a non-profit organization). Available: http://www.calflora.org/. (Accessed: Sep 11, 2008)

Canfield, J. E., L. J. Lyon, J. M. Hillis, and M. J. Thompson. 1999. “Ungulates.” In Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana, coordinated by G. Joslin and H. Youmans. Committee on Effects of Recreation on Wildlife, Montana Chapter of the Wildlife Society. In: 2008 Winter use plans environmental assessment. Yellowstone and Grand Teton National Parks and John D. Rockefeller, Jr. Memorial Parkway.

Carroll, C., R. F. Noss, and P. C. Paquet. 2001. Carnivores as focal species for conservation planning in the Rocky Mountain region. Ecological Applications 11:4, 961-980.

Copeland, J.P., J.M. Peek, C.R. Groves, W.E. Melquist, K.S. McKelvey, G.W. McDaniel, C.D. Long, C.E. Harris. 2007. Seasonal habitat associations of the wolverine in Central Idaho. Journal of Wildlife Management 71:2201-2212.

Davis, J. and J. Cohen. 2009. California habitat connectivity and wildlife movement studies. CSU Geopatial Review. San Francico State University. Vol. 7. Spring.

Department of Water Resources (DWR). June 2007. Climate Change in California. Accessed online at: http://www.water.ca.gov/climatechange/docs/062807factsheet.pdf.

Dorrance, M. J., P. J. Savage, and D. E. Huff. 1975. "Effects of Snowmobiles on White-Tailed Deer." Journal of Wildlife Management 39: 563-569.

Doyle, F.I. and J.M.N. Smith. 1994. Population responses of northern goshawks to the 10-yr cycle in numbers of snowshoe hares. In: Block, W.M., M.L. Morrison, and M.H. Reiser, editors. The Northern Goshawk: Ecology and Management. Studies in Avian Biology No. 16: 12-l 7, 1994.

Eckstein, R. G., T. F. O'Brien, O. J. Rongstad, and J. G. Bollinger. 1979. Snowmobile effects on movements of white-tailed deer: a case study. Environmental Conservation 6:45-51.

Eldorado National Forest Amador Ranger District. 2007. 2007-2008 Grooming Program and Policy. Prepared as a Part of the MOU Between California And Nevada Snowmobile Association (CNSA) and Eldorado National Forest - Amador Ranger District.

Epanchin, P.N. and A. Engilis, Jr. 2009. Mount Lyell shrew (Sorex lyelli) in the Sierra Nevada, California, with comments on alpine records of Sorex. The Southwestern Naturalist 54(3):354-357.

Fites-Kaufman, J., P. Rundel, N. Stephenson, and D.A. Weixelman. 2007. Montane and Subalpine Vegetation of the Sierra Nevada and Cascade Ranges. In: Barbour, M. G., T. Keeler-Wolf, and A. Schoenherr. Terrestrial Vegetation of California. 3rd Edition. University of California Press, Berkeley, CA.

Forest Issues Group. July 2009. 2001 Sierra Nevada Framework. http://www.forestissuesgroup.org

Franson, J. C., L. Sileo and N. J. Thomas. 1995. Causes of eagle deaths. In: LaRoe E. T., G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. Our living resources. U.S. Dept. Int., Natl. Biol. Serv., Washington, D.C.

Freddy, D. J., W. M. Bronaugh, and M. C. Fowler. 1986. Responses of mule deer to disturbance by persons afoot and snowmobiles. Wildlife Society Bulletin 14:63–68.

Goodrich, J.M., and J. Berger. 1994. Winter recreation and hibernating black bears. Biological Conservation 67:105-110.

Graham, R.T., R.T. Reynolds, M.H. Reiser, R.L. Bassett, and D.A. Boyce. 1994. Sustaining forest habitat for the northern goshawk: a question of scale. In: Block, W.M., M.L.

Morrison, and M.H. Reiser, editors. The Northern Goshawk: Ecology and Management. Studies in Avian Biology No. 16: 12-l 7, 1994.

Grinnell, J., J.S. Dixon, and J.M. Linsdale. 1937. Fur-bearing mammals of California. University of California, University of California Press, Berkeley.

Gutiérrez, R. J., A. B. Franklin, and W. S. Lahaye. 1995. Spotted Owl (Strix occidentalis), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/179.

International Snowmobile Manufacturers Association. 2008. Snowmobiling Facts: Sound. http://www.snowmobile.org/facts_sound.asp. October 6, 2008.

Keane, J.J. 2000. Northern goshawk: affected environment and environmental consequences. Sierra Nevada Forest Plan Amendment: Draft Environmental Impact Statement Volume 2, Pages 353-363. USDA Forest Service, Sacramento, CA.

Keddy, P.A., A.J. Spavold and C.J. Keddy. 1979. Snowmobile impact on old field and marsh vegetation in Nova Scotia, Canada: An experimental study. Dalhousie University, Nova Scotia; Environmental Mgmt 88(10): 409-415.

Kochert, M. N., K. Steenhof, C. L. Mcintyre, and E. H. Craig. 2002. Golden Eagle (Aquila chrysaetos), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/684.

Krohn, W.B., W.J. Zielinski, and R.B. Boone. 1997. Relations among fishers, snow and martens in California: results from small-scale spatial comparisons. In: G. Proulx, et al., editors. Martes: Taxonomy, ecology, techniques, and management. Provincial Museum of Alberta, Edmonton, Alberta, Canada.

Kruckeberg, A. 1984. California serpentines: flora, vegetation, geology, soils, and management problems. University of California Press, Berkeley. 180 pp.

Lela and White. 2002. Laboratory Testing of Snowmobile Emissions: Final Report. Southwest Research Institute. San Antonio, Texas. July 2002.

Long, C.A. 1973. Taxidea taxus. Mammalian Species. The American Society of Mammalogists. 26:1-4.

May, R., A. Landa, J. van Dijk, J.D.C. Linnell, and R. Andersen. 2006. Impact of infrastructure on habitat selection of wolverines Gulo gulo. Wildlife Biology 12:285-295.

McDonald. 1988. Montane Hardwood. In Mayer, K.E. and W.F. Laudenslayer,Jr., eds. A Guide to Wildlife Habitats of California. California Department of Forestry and Fire Protection. Sacramento, CA. pp. 72-73.

Meretsky, V. J., N. F. R. Snyder, S. R. Beissinger, D. A. Clendenen, and J. W. Wiley. 2000. Demography of the California condor: implications for reestablishment. Conserv. Biol. 14: 957–967.

Moriarty K.M., W.J. Zielinski, A.G. Gonzales, T.E. Dawson, K.M. Boatner, C.A. Wilson, F.V. Schlexer, K.L. Pilgrim, J.P. Copeland, and M.K. Schwartz. 2009. Wolverine confirmation in California after nearly a century: native or long-distance immigrant? Northwest Science 83:2. P. 154-162.

National Park Service. 2007. Winter Use Plans Final Environmental Impact Statement: Yellowstone and Grand Teton National Parks, John D. Rockefeller, Jr. Memorial Parkway. Volumes 1 and 2.

National Scenic Byways Program. 2008. National Scenic Byways: California. http://www.byways.org/explore/states/CA. November 17, 2008.

NatureServe Explorer. 2008. http://www.natureserve.org/index.jsp.

Neumann, P.W. and H.G. Merriam. 1972. Ecological effects of snowmobiles. Can. Field Naturalist 86(3):207-212.

Northern Sacramento Valley Planning Area (NSVPA). 2006 Air Quality Attainment Plan.

Northern Sierra Air Quality Management District (NSAQMD). 2005. Annual Air Monitoring Report.

Olliff, T., K. Legg, and B. Kaeding, editors. 1999. Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming.

Oregon Carex Working Group. 2008. Final Report of the Carex constanceana Survey for the Fremont-Winema National Forest. Unpublished Administrative Report.

Parker, K. L., C. T. Robbins, and T. A. Hanley. 1984. "Energy Expenditures for Locomotion by Mule Deer and Elk." Journal of Wildlife Management 48: 474-488.

Perrine, J. 2005. Ecology of Red Fox (Vulpes vulpes) in the Lassen Peak region of California, USA. Unpublished. Dissertation. University of California, Berkeley.

Perrine, J. D.; Arnold, J. F. 2001. A new wildlife sighting reporting and database system for Lassen Volcanic National Park. Transactions of the Western Section of The Wildlife Society 37: 8-15.

Perrine, J.D., L.A. Campbell, and G.A. Green. 2010. Sierra Nevada red fox (Vulpes vulpes necator): A conservation assessment. Pacific Southwest Research Station, USDA Forest Service, Vallejo, California.

Perrine, J.D., J. Pollinger, B. Sacks, R. Barrett, and R. Wayne. 2007. Genetic evidence for the persistence of the critically endangered Sierra Nevada red fox in California. Conservation Genetics. 8:1083-1095.

Polite, C. (1988-1990). California Condor. Life History Accounts and Range Maps – California Wildlife Habitat Relationships System. California Depart. of Fish and Game, Originally published in California's wildlife: Vol. I-III. Zeiner, D.C., W.F. Laudenslayer Jr., K.E. Mayer, and M. White, eds. California Department of Fish and Game, Sacramento, California. Retrieved from http://www.dfg.ca.gov/biogeodata/cwhr/cawildlife.aspx Accessed August 23, 2009.

Polite, C. and J. Pratt. (1988-1990; Updated by CWHR staff 1999.) Bald Eagle. Life History Accounts and Range Maps – California Wildlife Habitat Relationships System. Originally published in California's wildlife: Vol. I-III. Zeiner, D.C., W.F. Laudenslayer Jr., K.E. Mayer, and M. White, eds. California Department of Fish and Game, Sacramento, California. Retrieved from http://www.dfg.ca.gov/biogeodata/cwhr/cawildlife.aspx Accessed August 20, 2009.

Polite, C. and J. Pratt. (Updated by CWHR staff 2005.) Northern Goshawk. Life History Accounts and Range Maps – California Wildlife Habitat Relationships System. Originally published in California's wildlife: Vol. I-III. Zeiner, D.C., W.F. Laudenslayer Jr., K.E. Mayer, and M. White, eds. California Department of Fish and Game, Sacramento, California. Retrieved from http://www.dfg.ca.gov/biogeodata/cwhr/cawildlife.aspx Accessed August 20, 2009.

Poole, Alan F., Rob O. Bierregaard, and Mark S. Martell. 2002. Osprey (Pandion haliaetus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from http://bna.birds.cornell.edu/bna/species/683. Accessed August 21, 2009

Powell, R. A., S. W. Buskirk, and W. J. Zielinski. 2003. Fisher and marten. In G.A. Feldhamer, B.C. Thompson, and J. A. Chapman (Eds), Wild mammals of North America: Biology, management and conservation. 2nd ed, pp.635-649.

Risser, R. J. and M. E. Fry. 1988. Montane Chaparral. In: Mayer, K. E. and W. F. Laudenslayer, Jr., eds. 1988. A Guide to Wildlife Habitats of California. California Department of Forestry and Fire Protection, Sacramento, CA. pp. 102-103.

Roloff, David, Elizabeth Erickson, and Becca Niles. 2009. California Department of Parks and Recreation, Off-Highway Motor Vehicle Recreation Division 2009 Winter Trailhead Survey. California State University, Sacramento. Sacramento, California. June 2009.

Rowland, M.M., M.J. Wisdom, D.H. Johnson, B.C. Wales, J.P. Copeland, and F.B. Edelmann. 2003. Evaluation of landscape models for wolverines in the interior Northwest, United States of America. Journal of Mammalogy 84: 92-105.

Rubin, E. S., W. M. Boyce, and V. C. Bleich. 2000. Reproductive strategies of desert bighorn sheep. Journal of Mammalogy 81(3):769-786.

Sacramento Valley Air Quality Engineering and Enforcement Professionals (CVAQEEP). August 2009. Northern Sacramento Valley Planning Area 2009 Triennial Air Quality Attainment Plan. Accessed online at: http://www.airquality.org/SVBCC/2009/Sep18-TAC-Item7AttainmentPlan.pdf.

Sawyer, J. O., T. Keeler-Wolf, and J. Evens. 2009. A Manual of California Vegetation. California Native Plant Society. Sacramento CA.

Schempf, P.F. and M. White. 1977. Status of six furbearer populations in the mountains of northern California. U.S. Department of Agriculture, Forest Service. California Region. December.

Science Daily. April 3, 2008. "Preliminary DNA Analysis of New California Wolverine Does Not Match Historic Populations." http://www.sciencedaily.com/releases/2008/04/080403125451.htm

Seltenrich, C. P. and A. C. Pool. 2002. A standardized approach for habitat assessments and visual encounter surveys for the foothill yellow-legged frog (Rana boylii). Pacific Gas and Electric Company.

Snyder, Noel F. and N. John Schmitt. 2002. California Condor (Gymnogyps californianus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from http://bna.birds.cornell.edu/bna/species/610. Accessed August 23, 2009.

Squires, John R. and Richard T. Reynolds. 1997. Northern Goshawk (Accipiter gentilis), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from http://bna.birds.cornell.edu/bna/species/298. Accessed August 20, 2009.

Stangl, J.T., 1999. Effects of Winter Recreation on Vegetation. National Park Service: Effects of Winter Recreation on Wildlife:119-121.

State of California, Department of Finance (Dept. of Finance). 2007. Population Projections for California and Its Counties 2000-2050, Sacramento, California, July 2007.

______2010. E-1 Population Estimates for Cities, Counties and the State with Annual Percent Change — January 1, 2009 and 2010. Sacramento, California, May 2010.

TRA Environmental Sciences, Inc. 2008. Over Snow Vehicle Snow Program Cost Sharing Agreements Initial Study/Negative Declaration. Prepared for California Department of Parks and Recreation, Off-Highway Motor Vehicle Division. November 2008.

______2009. Over Snow Vehicle Snow Program Cost Sharing Agreements Initial Study/Negative Declaration. Prepared for California Department of Parks and Recreation, Off-Highway Motor Vehicle Division. September 2009.

University of California, Davis (U.C. Davis), Wildlife Habitat Center. 2006. California Wildlife: Conservation Challenges (California's Wildlife Action Plan). Prepared for the California Department of Fish and Game. March.

______Cooperative Extension at Davis. 2010. California Fish Website. Retrieved from http://ucce.ucdavis.edu/datastore/datastoreview/showpage.cfm? usernumber = 117&surveynumber=241. Accessed February 7, 2010.

U.S. Department of Interior (USDI). 2004. Lower Klamath Basin Science Conference Abstracts. http://www.usbr.gov/research/science-and-tech/conference/lowerklamath/rankingresults/abstractreport.cfm. June 2004.

U.S. Environmental Protection Agency (EPA). September 8, 2008. 8-hour Ozone Non-attainment State Map. http://www.epa.gov/air/oaqps/greenbk/ca8.html.

______2010. Fact Sheet – EPA and NHTSA to Propose Greenhouse Gas and Fuel Efficiency Standards for Heavy-Duty Trucks; Begin Process for Further Light Duty Standards. May 2010. Available online at: http://www.epa.gov/oms/climate/regulations/420f10038.pdf

U.S. Fish and Wildlife Service (USWFS). 1986. Recovery Plan for the Pacific Bald Eagle. Portland, Oregon. 163pp.

______2004. Endangered and Threatened Wildlife and Plants: 12-month Finding for a Petition to List the West Coast Distinct Population Segment of the Fisher (Martes pennanti): Proposed Rule. 50 CFR Part 17. April 8, 2004.

______2005. Species Account California Spotted Owl (Strix occidentalis occidentalis). Sacramento, CA. Retrieved from http://www.fws.gov/sacramento/es/animal_spp_acct/ca_spotted_owl.htm. Accessed August 21, 2009.

______2008a. Recovery plan for the northern spotted owl, Strix occidentalis caurina. USFWS, Portland, Oregon. 158 pp.

______2008b. Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition to List the North American Wolverine as Endangered or Threatened. 73 Federal Register 48 (March 11) pp. 12,929-12,941.

______2010a. Slender orcutt grass species account. Sacramento U.S. Fish and Wildlife Office.

______2010b. Lahontan cutthroat trout. Nevada Fish and Wildlife Office Protected Species Pages. Retrieved at http://www.fws.gov/Nevada/protected_species/fish/species/lct.html. Accessed February 8, 2010.

U.S. Forest Service (USFS). 1988. Land Resource Management Plan, Inyo National Forest. San Francisco, CA: United States Department of Agriculture. Pacific Southwest Region.

______1989. Land Resource Management Plan, Eldorado National Forest. San Francisco, CA: United States Department of Agriculture. Pacific Southwest Region.

______1995a. Land Resource Management Plan, Klamath National Forest. San Francisco, CA: United States Department of Agriculture. Pacific Southwest Region.

______1995b. Land Resource Management Plan, Shasta-Trinity National Forest. San Francisco, CA: United States Department of Agriculture. Pacific Southwest Region.

______1998. Conservation agreement: Upper McCloud River redband trout. Shasta-Trinity National Forest. Retrieved at http://www.fs.fed.us/r5/shastatrinity/documents/st-main/recreation/st-main/st-fishing/redband-trout-conservation-document-cover.shtml. Accessed February 8, 2010.

______2000. Water Quality Management for Forest System lands in California Best Management Practices. Pacific Southwest Region.

______2001. Sierra Nevada Forest Plan Amendment Final Environmental Impact Statement. Forest Service. Pacific Southwest Region, Sacramento, CA.

______2003a. Biological Assessment for Sierra Nevada Forest Plan Amendment. Supplemental Environmental Impact Statement. Pacific Southwest Region. Vallejo, CA.

______2003b. Inyo National Forest. 2003/2004 OSV O&M Grant Application. Wildlife Habitat Protection Program (WHPP)/Habitat Management Program (HMP). May 7, 2003.

______2003c. Klamath National Forest 2003/2004 OSV Area Management Grant Application. Wildlife Habitat Protection Program (WHPP)/Wildlife, Fish, and Plants Habitat Management Program (HMP). June 25, 2003.

______2003d. Lassen National Forest OSV O&M Grant Application. Wildlife Habitat Protection Program (WHPP)/Wildlife, Fish, and Plants Habitat Management Program (HMP). May 16, 2003.

______2003e. Modoc National Forest 2003/2004 OSV O&M Grant Application. Wildlife Habitat Protection Program (WHPP)/Wildlife Habitat Management Program (HMP). Doublehead Ranger District. June 26, 2003.

______2003f. Plumas National Forest 2004 Winter O&M Grant Application. Wildlife Habitat Protection Program (WHPP)/Wildlife, Fish, and Plants Habitat Management Program (HMP). May 15, 2003.

______2003g. Sequoia National Forest 2004 OSV O&M Grant Application. Wildlife Habitat Protection Program (WHPP)/Wildlife, Fish, and Plants Habitat Management Program (HMP). May 14, 2003.

______2003h. Shasta-Trinity National Forest 2004 OSV O&M Grant Application. Wildlife Habitat Protection Program (WHPP)/ Wildlife, Fish, and Plants Habitat Management Program (HMP). May 13, 2003.

______2003i. Sierra National Forest. 2003/2004 OSV O&M Grant Application. Wildlife Habitat Protection Program (WHPP)/ Habitat Management Program (HMP). May 12, 2003.

______2003j. Stanislaus National Forest 2004 OSV O&M Grant Application. Wildlife, Fish, and Plants Habitat Management Program (HMP). May 15, 2003.

______2003k. Tahoe National Forest 2003/2004 Summer OHV and Winter OSV Grant Application. Wildlife Habitat Protection Program (WHPP)/ Wildlife Habitat Management Program (HMP). Foresthill Ranger District. June 26, 2003.

______2004a. Sierra Nevada Forest Plan Monitoring Accomplishment Report. Retrieved from http://www.fs.fed.us/r5/snfpa/.

______2004b. Sierra Nevada Forest Plan (Framework) Amendment, Final Supplemental Environmental Impact Statement. http://www.fs.fed.us/r5/snfpa/final-seis/.

______2005. Stanislaus Forest Plan Direction, Stanislaus National Forest. San Francisco, CA: United States Department of Agriculture. Pacific Southwest Region.

______2007a. Sierra Nevada Forest Plan Monitoring Accomplishment Report. Retrieved from http://www.fs.fed.us/r5/snfpa/.

______2007b. Eldorado National Forest 2008 OHV Grant Application WHPP/HMP. OHV Form F. September 13, 2007.

______2007c. Inyo National Forest 2008 OHV Grant and Cooperative Agreement Application. Wildlife Habitat Protection Program (WHPP)/ Habitat Management Program (HMP). September 11, 2007.

______2007d. Tahoe National Forest 2008 OHV Grant Application WHPP/HMP. September 10, 2007.

______2008. Final Environmental Impact Statement – Public Wheeled Motorized Travel Management EIS, Eldorado National Forest. San Francisco, CA: United States Department of Agriculture. Pacific Southwest Region.

______2009a. About Us Page. San Francisco, CA. Pacific Southwest Region Accessed on Tue, Apr. 21, 2009 from http://www.fs.fed.us/r5/eldorado/about/.

______2009b. Draft Environmental Impact Statement –Motorized Travel Management plan DEIS, Inyo National Forest. San Francisco, CA: United States Department of Agriculture. Pacific Southwest Region.

______2009c. OSV Snow Program Monitoring Checklists. Prepared by Klamath, Modoc, Shasta-Trinity, Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Inyo, Sierra, and Sequoia National Forests. Prepared for California State Parks, Off-Highway Motor Vehicle Recreation (OHMVR) Division.

______2009d. National Visitor Use Monitoring Results. Data Collected Fiscal Year 2007. Eldorado National Forest. Last Updated 12 January 2009.

______2009e. National Visitor Use Monitoring Results. Data Collected Fiscal Year 2006. Inyo National Forest. Last Updated 24 March 2009.

______2009f. National Visitor Use Monitoring Results. Data Collected Fiscal Year 2008. Klamath National Forest. Last Updated 5 August 2009.

______2009g. National Visitor Use Monitoring Results. Data Collected Fiscal Year 2005. Lassen National Forest. Last Updated 9 February 2009.

______2009h. National Visitor Use Monitoring Results. Data Collected Fiscal Year 2006. Modoc National Forest. Last Updated 24 March 2009.

______2009i. National Visitor Use Monitoring Results. Data Collected Fiscal Year 2005. Plumas National Forest. Last Updated 19 February 2009.

______2009j. National Visitor Use Monitoring Results. Data Collected Fiscal Year 2006. Sequoia National Forest. Last Updated 30 January 2009.

______2009k. National Visitor Use Monitoring Results. Data Collected Fiscal Year 2008. Shasta-Trinity. Last Updated 5 August 2009.

______2009l. National Visitor Use Monitoring Results. Data Collected Fiscal Year 2007. Sierra National Forest. Last Updated 27 January 2009.

______2009m. National Visitor Use Monitoring Results. Data Collected Fiscal Year 2007. Stanislaus National Forest. Last Updated 12 January 2009.

______2009n. National Visitor Use Monitoring Results. Data Collected Fiscal Year 2005. Tahoe National Forest. Last Updated 18 February 2009.

______2010. “Rare red fox sighting confirmed on Humboldt-Toiyabe.” Press release. September 2, 2010.

University of California, Davis. (UC Davis). 2006. California Wildlife: Conservation Challenges (California’s Wildlife Action Plan). Wildlife Habitat Center. Prepared for the California Department of Fish and Game. March 2006.

Wake, D. B. and T. J. Papenfuss. 2005. Mt. Lyell Salamander. In M. Lannoo (Ed), Amphibian declines: The conservation status of United States species. University of California Press. Retreived from http://amphibiaweb.org/. Accessed February 9, 2010.

Weaver, T. and Dale, D. 1978. Trampling Effects of Hikers, Motorcycles and Horses in Meadows and Forests. Journal of Applied Ecology 15: 451-457.

Western Regional Climate Center. 2009. California Climate. http://www.wrcc.dri.edu/narratives/CALIFORNIA.htm. Accessed August 25, 2009.

White, Clayton M., Nancy J. Clum, Tom J. Cade, and W. Grainger Hunt. 2002. Peregrine Falcon (Falco peregrinus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/660.

Winter Wildlands Alliance. 2006. Winter Recreation on Western National Forest Lands A Comprehensive Analysis of Motorized and Non-Motorized Opportunity and Access. Boise, Idaho. July 2006.

Zieliski, W. J., R. L. Truex, F. V. Schlexer, L. A. Campbell, and C. Carroll. 2005. Historical and contemporary distributions of carnivores in forests of the Sierra Nevada, California, USA. Journal of Biogeography 32:1385-1407.

Zielinski, William J., Keith M. Slauson and Ann E. Bowles. 2007. The Effect of Off-Highway Vehicle Use on the American Marten in California, USA. Final Report to the USDA Forest Service, Pacific Southwest Region, and California Department of Parks and Recreation, Off-Highway Motor Vehicle Recreation Division. Sacramento.

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Modoc National Forest, Anthony Hewitt, Geographer
Plumas National Forest, Susan Barron, Forest IWEB/SUDS Coordinator
Plumas National Forest, Ralph Martinez, GIS Coordinator
Sequoia National Forest, Nolan Fritz, Recreation Manager
Sequoia National Forest, Chris Sanders, Assistant Forest Recreation Officer
Sequoia National Forest, Heidi Hosler, GIS Coordinator
Sierra National Forest, Robbin Ekman, Recreation Officer
Shasta National Forest, Ed Hatakeda, Recreation Forester
Shasta National Forest, Val Hall, Recreation Technician
Stanislaus National Forest, Sue Warren, Route Designation ID Team Leader
Stanislaus National Forest, Lonnie Allison

Stanislaus National Forest, Carly Gibson, GIS Coordinator
Tahoe National Forest, David Michael, Trails and OHV Program Manager
Tahoe National Forest, John Babin, GIS Coordinator

11.3 REPORT PREPARERS

California Department of Parks and Recreation, OHMVR Division

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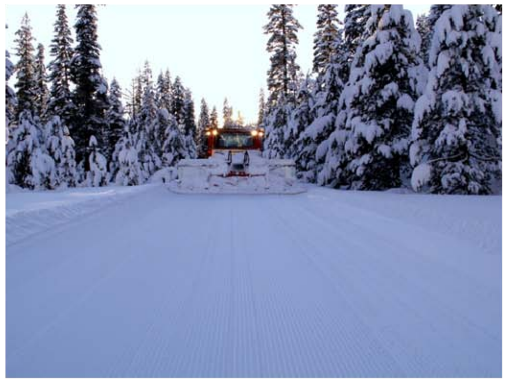
Christina Lau, Analyst	
Tom Reid, Senior Technical Analyst	

Over Snow Vehicle Program
Final Environmental Impact Report
Program Years 2010 – 2020

State Clearinghouse # 2009042113

December 2010

State of California
Department of Parks and Recreation
Off-Highway Motor Vehicle Recreation (OHMVR) Division

Over Snow Vehicle Program
Final Environmental Impact Report
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Prepared for:
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Off-Highway Motor Vehicle Recreation (OHMVR) Division
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INTRODUCTION

This document, together with the Draft EIR, comprises the Final EIR for the Over Snow Vehicle (OSV) Program. This document is prepared as an informational document for action by the California Department of Parks and Recreation (CDPR) Off-Highway Motor Vehicle Recreation (OHMVR) Division on the funding of the OSV Program for Program Years 2010 – 2020.

Per CEQA Guidelines Section 15132, the Final EIR shall consist of:

a) The Draft EIR for a revision of the draft.

b) Comments and recommendations received on the draft EIR either verbatim or in summary.

c) A list of persons, organizations, and public agencies commenting on the Draft EIR.

d) The responses of the Lead Agency to significant environmental points raised in the review and consultation process.

e) Any other information added by the Lead Agency.

The Final EIR for the Over Snow Vehicle Program, Program Years 2010 – 2020, has the following organization:

Draft EIR (bound as a separate document)

Final EIR (sections bound with this document)

1.0 Public Comments on Draft EIR. This section contains copies of the comment letters and email communications received on the Draft EIR during the public review period from October 7 to November 21, 2010, as well as a summary of the oral comments made during the OHMVR Division public meeting on October 27, 2010. The comment letters have been individually numbered. A list of those who commented is provided at the front of the section.

2.0 Responses to Comments. This section provides a written response by the OHMVR Division as Lead Agency to each substantive comment raising an environmental issue submitted on the Draft EIR.

3.0 Text Amendments to the Draft EIR. In response to comments, some changes have been made to the EIR text. The changes correct inaccuracies and clarify the analysis in the Draft EIR. Where text in the Draft EIR has been deleted, the text is marked with ~~strike-out~~. <u>Underlined</u> text represents new text added to the Draft EIR.

Attachments. Additional information on sno-parks is presented in Attachment A. Annual OSV registration data is presented in Attachment B.

1.0 PUBLIC COMMENT ON DRAFT EIR

COMMENT LETTERS
(Received during public review period from October 7 to November 22, 2010)

Public Agencies

1. Lassen National Forest

Organizations

2. Center for Biological Diversity
3. Recreation Outdoors Coalition
4. Snowlands Network

Individuals

5. Elizabeth Norton
6. Byron Baker
7. Michael Evans
8. Paul Juhnke
9. Bill Harbaugh
10. Steve Moulis
11. Steve Rounds
12. Jeff Erdoes

ORAL COMMENTS
(Received at the OHMVR Division Meeting, October 27, 2010)

13. Patrick Lietske, Lassen National Forest, Wildlife Biologist
14. Byron Baker, Sierra Buttes SnowBusters, Volunteer Groomer

STATE OF CALIFORNIA

Governor's Office of Planning and Research

State Clearinghouse and Planning Unit

Arnold Schwarzenegger
Governor

Cathleen Cox
Acting Director

November 23, 2010

Connie Latham
California Department of Parks and Recreation
1725 23rd. Street, Suite 200
Sacramento, CA 95816

Subject: Over Snow Vehicle Snow Program Challenge Cost Share Agreements
SCH#: 2009042113

Dear Connie Latham:

The State Clearinghouse submitted the above named Draft EIR to selected state agencies for review. The review period closed on November 22, 2010, and no state agencies submitted comments by that date. This letter acknowledges that you have complied with the State Clearinghouse review requirements for draft environmental documents, pursuant to the California Environmental Quality Act.

Please call the State Clearinghouse at (916) 445-0613 if you have any questions regarding the environmental review process. If you have a question about the above-named project, please refer to the ten-digit State Clearinghouse number when contacting this office.

Sincerely,

Scott Morgan

Scott Morgan
Director, State Clearinghouse

Document Details Report
State Clearinghouse Data Base

SCH# **2009042113**
Project Title Over Snow Vehicle Snow Program Challenge Cost Share Agreements
Lead Agency Parks and Recreation, Department of

Type **EIR** Draft EIR

Description OHMVR Division proposes snow program funding in 11 National Forests for the operation, maintenance and grooming of winter recreation trails and trailheads within the Project Area. The groomed trails are predominately maintained for snowmobile of OSV use. The project locations extend from the Oregon border south towards Bakersfield. In total, the Project involves plowing 97 miles of access road, plowing and maintaining 34 trailhead parking areas (garbage collection and restroom cleaning), and grooming ~1,761 miles of trail.

Lead Agency Contact

Name Connie Latham
Agency California Department of Parks and Recreation
Phone 916-324-3558 ***Fax***
email
Address 1725 23rd. Street, Suite 200
City Sacramento ***State*** CA ***Zip*** 95816

Project Location

County El Dorado, Inyo, Lassen, Modoc, Plumas, Shasta, Trinity, ...
City
Region
Lat / Long
Cross Streets
Parcel No.
Township ***Range*** ***Section*** ***Base***

Proximity to:

Highways
Airports
Railways
Waterways
Schools
Land Use

Project Issues Cumulative Effects; Landuse; Noise; Recreation/Parks; Vegetation; Air Quality; Biological Resources; Forest Land/Fire Hazard; Water Quality; Wetland/Riparian

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Reviewing Agencies Resources Agency; Department of Conservation; Department of Fish and Game, Headquarters; Office of Historic Preservation; Department of Water Resources; California Highway Patrol; Caltrans, Division of Transportation Planning; State Water Resources Control Board, Division of Water Quality; Native American Heritage Commission; State Lands Commission; Cal Fire

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Date Received 10/07/2010 ***Start of Review*** 10/07/2010 ***End of Review*** 11/22/2010

Note: Blanks in data fields result from insufficient information provided by lead agency.

Comment Letter #1: Lassen National Forest

United States Department of Agriculture **Forest Service** **Lassen National Forest**

2550 Riverside Drive
Susanville, CA 96130
(530) 257-2151 Voice
(530) 252-6624 TTY
(530) 252-6428 Fax

File Code: 1580/1920
Date: November 5, 2010

Connie Latham
Project Manager
California State Parks, Off-Highway Motor Vehicle Recreation Division
PO Box 942896
Sacramento, CA 95816

Dear Ms. Latham:

In reference to the OSV Program Draft Environmental Impact Report (EIR), we are posting two documents at **osvprogrameir@parks.ca.gov** for your consideration during the public comment period. The first document is composed of excerpts from the EIR document with comments using Track Changes. The second document is a monitoring report titled *Over Snow Vehicle (OSV) Snow Program Monitoring Report per EIR Data Request Related to the OSV Snow Program*, Lassen National Forest. This report was completed with contributing funds from the 2009 Collection Agreement 10-CO-11050650-008.

If you have any questions regarding these two documents, please contact Tom Frolli, Wildlife Program Manager, at (530) 252-6661, or tfrolli@fs.fed.us, or Chris O'Brien, Public Services Officer, at (530) 252-6698, or cobrien@fs.fed.us. Thank you for the opportunity to comment on this important environmental analysis.

Sincerely,

/s/ Jerry Bird
JERRY BIRD
Forest Supervisor

cc: Chris J Obrien

California OHMVR Division
2010 OSV Program Draft EIR Comments

Lassen National Forest
Supervisors Office
2550 Riverside Drive
Susanville, CA 96130

The 2010 OSV Draft EIR evaluates the existing program for a ten year financial commitment (2010-2020) for managing groomed OSV Snow parks and trail systems at 26 locations across 11 National Forests in the State of California. The following comments to the DEIR relate to biological resources on the Lassen National Forest. Excerpts from the DEIR document were copied so that specific comments could be attached.

Page S-1

OSV Program trails are used each year by an estimated 159,000 OSVs bringing upwards of 200,000 visitors to the Project Area. Growth in OSV ownership has occurred at an average annual rate of 4% since 1997. Assuming the same growth rate, project trails may have an annual OSV usage of 235,000 and 300,000 visitors by 2020. To accommodate the increased demand for motorized winter trails, the OHMVR Division anticipates expanding the groomed trail system to include new groomed trail locations, expanded trailhead parking areas, and increased frequency of grooming operations on existing trail systems. Presently, OSV Program equipment operations involve 2,076 snow removal (plowing and/or blowing) hours and 4,948 grooming hours throughout the Project Area. Projected growth by 2020 would increase equipment operations by 700 plowing hours and 1,100 grooming hours.

Comment [LNF 1]: With the predicted increases in OSV users by 2020, it is realistic to expect that the significance of various impacts may change. Therefore, it is important to anticipate increased indirect costs related to required law enforcement, biological monitoring etc. and not just for providing more trails, more trailheads and more grooming. The DEIR takes the approach that new opportunities will be needed in the future, but assumes that costs for handling the indirect consequences will be passed on to the Forest Service.

Table S-1. Summary of Project Impacts and Mitigation Measures
LAND USE PLANS AND POLICIES

BIOLOGICAL RESOURCES
IMPACT: Northern spotted owls and northern goshawks occur within or near the Project Area. USFS actively monitors nesting habits and fledgling success. Management actions are currently in place that reduce the potential effects of OSV recreation on northern goshawks and northern spotted owls to a less than significant level. The USFS employs adaptive management. Thus, based upon the results of the Regional Northern Goshawk Focused Study and the Northern Spotted Owl Focused Study, biologists may revise the USFS Management Actions.
Less than Significant Impact
Measure BIO-1: USFS shall incorporate the results of the northern goshawk and northern spotted owl studies into management actions and report these actions to the OHMVR Division for incorporation into the OSV Program as soon as revised USFS management actions are formulated.
Less than Significant Impact After Mitigation.

Comment [LNF 2]: The results of the Regional commissioned focus studies have not been released at this date, therefore it is premature to assume that these Focused Studies have detected no relationship between OSV recreation and Spotted owl and Northern goshawk reproductive behavior.

Comment [LNF 3]: The type of monitoring required to detect changes in northern goshawk and spotted owl reproductive behavior (disturbance avoidance) may require supplemental monitoring and GIS analysis in order to mitigate any potential impact. This type of monitoring is not part of typical USFS wildlife or recreation budget, and is not covered by regular funding provided by OHMVR Division.

IMPACT: California wolverine is not known to be present near OSV sites. If present, disturbance caused by OSV activities may adversely affect California wolverine natal denning behaviors.
Potentially Significant Impact

Comment [LNF 4]: A systematic monitoring program for wolverine, as it relates to OSV is not in place. Only one wolverine has been detected in recent history within the State of California. We disagree that this one detection would lead to a potentially significant impact.

Measure BIO-2: USFS shall continue to work with the Pacific Southwest Research Station and other partners to monitor for presence of California wolverine. If there are verified wolverine sightings, USFS shall conduct an analysis to determine if OSV use within 5 miles of the detection have a potential to affect wolverine and, if necessary, a LOP from January 1 to June 30 will be implemented to avoid adverse impacts to potential breeding.
Less than Significant Impact After Mitigation.

IMPACT: Disturbance caused by OSV activities may adversely affect Sierra Nevada red fox breeding behaviors, home range use, and/or establish trailhead scavenging and begging behaviors.
Potentially Significant Impact

Measure BIO-3: Educational materials shall be provided on red fox and the importance of minimizing direct contact with red foxes at each trailhead. USFS shall provide the results of Sierra Nevada red fox inventory and monitoring currently being performed by wildlife biologists from the Forest Service, CDFG, and the University of California, Davis, to the OHMVR Division. USFS shall work with CDFG, the University of California, Davis, OHMVR, and other partners to continue inventory and monitoring in the Sierra Nevada, including the Project Area where the red fox is most likely to occur (e.g., Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Sierra, Inyo, and Sequoia National Forests). For those portions of the Project Area where presence is confirmed, USFS shall conduct an analysis to determine if OSV use within 5 miles of the detection have a potential to affect Sierra Nevada red fox and, if necessary, a LOP from January 1 to June 30 will be implemented to avoid adverse impacts to potential breeding. The USFS will evaluate activities for a 2-year period for detections not associated with a den site. In addition, if monitoring or other scientific information shows disturbance of Sierra Nevada red fox behaviors within the Project Area, the USFS shall implement suitable management actions to reduce any adverse impacts to a less than significant level. These management actions may include signage, barriers, LOPs, limits on night riding, trail closures, or reroutes of selected portions of OSV trails.
Less than Significant Impact After Mitigation.

Comment [LNF 5]: **Sentence reads awkwardly**. Suggested alteration: Educational materials shall be provided at each trailhead concerning red fox, and the importance of minimizing contact with this species.

Comment [LNF 6]: The conservation assessment (Perrin et al 2010) for this species and should be incorporated by reference. A systematic monitoring strategy has not been implemented on the Lassen NF relating to the OSV program and potential affects from OSV related disturbance.

IMPACT: OSV off-trail riding in low snow conditions could adversely impact individuals and/or populations of CRPR-listed 1B and 2 plant species and FSS plant species.
Potentially Significant Impact

Comment [LNF 7]: Personal observations of OSV activity on Lassen NF demonstrated that OSV users continued using groomed routes and trailheads into May (2009) regardless of extremely low snow conditions at that date.

Comment [LNF 8]: It would be interesting to hear a LNF hydrologist's opinions concerning whether LNF's lack of a minimal snow level has consequences for soil compaction/ disturbance.

IMPACT: If inventories and subsequent monitoring show that OSV use is damaging CNPS or FSS populations, the OSV Program would conflict with forest-wide LRMP biodiversity S&Gs in several national forests which require maintenance of viable populations of native plant species or sensitive plant species (Appendix D, Table 1).
Potentially Significant Impact

Measure BIO-4: The USFS will do one of the following: (1) Only permit OSV use on the groomed trail system and adjacent concentrated-use riding areas when there is sufficient snow cover (minimum snow depth of 12 inches) to protect soil and vegetation; (2) Inventory the groomed trail system and adjacent concentrated-use riding areas for all CRPR 1B, CRPR 2, and FSS plant species not already monitored by USFS (Table 5-6) for OSV impacts. Surveys shall focus on locations that are chronically exposed to OSV use and where plants listed in Table 5-6 have a potential for occurrence and exposure to OSV impacts. The USFS shall conduct public outreach with educational materials until resource surveys are complete. Educational materials shall include information that discourages OSV travel over bare ground, exposed vegetation, and snow less than 12 inches deep, including a description of the special-status plant species potentially affected and the adverse effects on those species. The species previously assessed and not included in this Mitigation Measure include Kern Plateau milk-vetch, Hall's daisy, Kern River daisy, and Kern Plateau horkelia, Mono milk-vetch, Mono Lake lupine, slender Orcutt grass, Barron's

buckwheat, and Columbia yellow cress. Follow-up monitoring shall be conducted for those species where presence is confirmed to ensure any protective measures needed to address OSV impacts are identified, implemented, and effective. Protective measures that shall be implemented when needed to avoid damage to special-status plants from OSVs include trail reroutes, barriers, seasonal closures, signage, and/or public education; or (3) Annually monitor the groomed trail system and adjacent concentrated-use riding areas where plants listed in Table 5-6 have a potential for occurrence. Monitoring shall focus on locations that are chronically exposed to OSV use and where plants listed in Table 5-6 have a potential for occurrence and exposure to OSV impacts. If this monitoring reveals impacts, USFS shall implement protective measures (e.g., temporary fencing, barriers, seasonal closures, signage, trail re-routes, public education, etc.) to restrict access and prevent further damage to these plants and engage in public education. Follow-up monitoring shall be conducted to ensure that protective measures are implemented and effective.
Less than Significant Impact After Mitigation.

IMPACT: Chronic disturbance caused by OSVs riding during low-snow conditions over wetlands, riparian areas, streams, and lake ice can adversely affect aquatic communities.
Potentially Significant Impact

Measure BIO-5: USFS shall annually monitor aquatic resources in the Project Area near the groomed trail system for damage by OSV use during low-snow conditions. If these assessments reveal impacts, USFS shall implement protective measures (e.g. fencing, signage, trail reroutes, etc.) to restrict access and prevent further resource damage and engage in public education.
Less than Significant Impact After Mitigation.

2.9 OSV Program Administration (pg 2-28 in DEIR)

2.9.1 OSV Program Funding

OSV Program activities are funded by the OHV Trust Fund and dispersed through one of two funding mechanisms. Annual funding of OSV Program operation and maintenance activities primarily occurs through the 2002 BCP which secured OSV Program funding from the OHV Trust Fund. The BCP allows for up to $1,000,000 to support grooming, plowing, and facility maintenance operations. The total amount encumbered each year varies somewhat based on anticipated fuel and labor costs and length of the snow season. The OSV Program has consistently provided roughly $900,000 annually over the past six years (2004 through 2010). Provided funds which have not been spent at the end of the contract period revert back to the OHV Trust Fund. Currently, 11 national forests and three county agencies as shown in Table 2-11 receive funding through the BCP for grooming, plowing, and facility maintenance services described above in Section 2.4.

The second funding mechanism for OSV Program related activity is the Grants Program. Whereas the BCP strictly funds grooming, plowing, and facility maintenance activities, the Grants Program funds can be used to fund supplemental OSV activities not allowed under the BCP such as purchase and maintenance of equipment and administrative support services described in Section 2.4.4. Historically, the Grants Program has not funded OSV Program related activities since the BCP was established. However, in 2010, five national forests were granted one-time funds totaling $227,445 for equipment purchases and supplemental staffing for cleaning maintenance, visitor contacts, and/or resource monitoring as shown in Table 2-11. Typical funding levels expected over the 10-year program period may increase reflective of

Comment [LNF 9]: General Comment 1 (all Mitigation Measures) There needs to be a discussion between OHMVR personnel and USFS personnel concerning what portion of the required mitigation is met by current USFS work plans. Work which is extraneous to those work plans (biological monitoring, recreation protective measures, law enforcement, public education) needs to be clarified. The language in the mitigation measures currently implies that required biological monitoring activities are covered by existing monitoring efforts already in the work plans.

Comment [LNF 10]: General Comment 2 (all Mitigation Measures) There is language in several of the measures (Measures 3, 4 and 5, see highlighted sections) which would, obligate or potentially obligate, the Forest Service to complete intensive, OSV Program-specific monitoring projects as part of the proposed mitigation measures. There is no discussion about how these monitoring efforts would be funded.

Comment [LNF 11]: This amounts to an average of $45,489 per forest. How much of this funding is allocated to resource monitoring? After equipment purchases and maintenance are subtracted from distributed grant funds, support to monitoring appears to be very low.

LNF Perspective
In 2010, Lassen NF received approx. $7000 to conduct Forest-wide analysis and monitoring of Spotted owl and Northern goshawk PACs. Lassen NF also spent internal funds in conducting this monitoring. Lassen NF did not have funds allocated to conduct other monitoring mentioned in the 5 Biological Mitigation Measurers (pgs S2 to S5)

program growth levels described in Section 2.7 above. Such increases would be subject to availability of OHV Trust Funds. The OHV Trust Fund has a fluctuating revenue source (OHV registration fees, gas tax, and State Vehicular Recreation Area fees) and supports other OHV related programs in addition to the OSV Program.

2.9.2 OSV Program Administration (pg 2-29 in DEIR)

Under the proposed 10-year program period, the OHMVR Division would issue multi-year contracts to each participating agency. Prior to annual release of OSV Program funds, each recipient must submit to the OHMVR Division the following data from the prior season: 1) Summary log of equipment hours for the season, 2) Monitoring checklist forms completed for all trails, 3) Summary log of patrol hours on trails and any enforcement actions taken, 4) Vehicle count at trailheads on weekend patrol days, 5) Summary of OSV trespass incidents and management actions taken or planned, 6) Demonstration of compliance with any OSV Program mitigation measures identified in this EIR. County recipients of OSV Program funds are responsible only for plowing or grooming and
would report only on equipment hours since national forests conduct the resource monitoring and enforcement patrols.

OHMVR Division would review all end of the season reports submitted by the OSV Program CSA and contract recipients to determine whether all required resource monitoring and patrols have occurred and that recipients are in compliance with OSV Program requirements. Based upon this review, the OHMVR Division would make an administrative finding as to whether each recipient is in compliance with the OSV Program requirements and whether contracts would be issued for the following winter season. If during the course of its review, OHMVR Division determines that a recipient is not in compliance with the OSV Program requirements, the OHMVR Division would make an administrative finding of non-compliance and would not renew the contract with that agency until compliance can be demonstrated.

Comment [LNF 12]: The guidelines disseminated to Forests concerning what level of resource monitoring is required to be "in compliance" with the OSV Program requirements are vague; standardized monitoring protocols need to be clarified.

Pg 2-29

Table 2-11. OSV Program Funding, BCP Contract Years 2004 through 2010 and Grants Program Year 2010

Funding Recipient	BCP Funding				Grants Funding
	2-Yr Contract 2004-2006	2-Yr Contract 2006-2008	1-Yr Contract 2008-2009	1-yr Contract 2009-2010	1-yr Grant 2010
Lassen NF	190,886	155,000	84,500	84,500	
Butte County	220,590	100,000	60,000	60,000	
Sierra County	80,000	220,000	118,500	118,500	
Plumas County	129,382	130,000	105,250	105,250	
Plumas NF	132,250	142,000	49,000	49,000	51,500
Tahoe NF	76,000	112,000	65,500	65,500	46,500
Eldorado NF	81,560	80,000	30,000	30,000	
Humboldt-Toiyabe NF	0	0	0	0	105,000
Stanislaus NF	213,000	194,000	120,500	120,500	6,650
Inyo NF	72,200	74,000	42,000	42,000	
Sierra NF	140,000	127,000	76,062	76,062	
Sequoia NF	283,234	202,200	106,100	106,100	17,795
Totals	**1,787,860**	**1,779,400**	**977,012**	**977,012**	**227,445**

Grants funding

Comment [LNF 13]: The allocation of grant funds is that USFS is "required" by agreements with OHMVR to conduct resource monitoring, which in some cases is outside the scope of district/ forest-level biological programs. Standardized monitoring protocols and associated funding is needed.

3.3.3 10-Year Program Growth, Year 2020
3.3.3.1 Conformance with Land Use Plans and Policies

Biology (pg 3-17)

Growth in OSV Recreation. Increased OSV use in off-trail riding areas along the groomed trail system could result in increased impact to CRPR and FSS plant species which are potentially present but have not been inventoried and are not monitored by the USFS. As described in Section 3.3.2.1 above, implementation of Measure BIO-3 would bring the OSV Program into to conformance with LRMP S&Gs and management prescriptions governing biological resources.

Comment [LNF 14]: Should include BIO-3 and BIO-4. This could be problematic on Lassen NF, as off-trail riding continues off of the groomed trail system in low snow depth conditions. Lassen NF currently does not have a Minimum Snow Depth cutoff in place.

5.2.5 Wildlife (pg 5-9)
5.2.6 Wildlife Movement Corridors

Habitat corridors facilitate wildlife migration and movement within landscapes, and are essential to the viability and persistence of many wildlife populations. Wildlife movement includes migration (i.e., usually one-way per season), inter-population movement (i.e., long-term genetic flow), and small travel pathways (i.e., daily movement corridors within an animal's territory).

Comment [LNF 15]: It is not currently known how much of a impact that OSV routes might have on wildlife movement corridors. It seems unlikely that traffic frequency would be high enough to create a deterrent.

While small travel pathways usually facilitate movement for daily home range activities, such as foraging or escape from predators, they also provide connection between outlying populations and the main corridor, permitting an increase in gene flow among populations. These linkages among habitats can extend for miles and occur on a large scale throughout California. The Cascades and Sierra Nevada are understudied in regards to habitat connectivity patterns (Davis and Cohen 2009); however, the importance of wildlife corridors should not be under-estimated. Wildlife corridors are undoubtedly important to the long-term health of wildlife populations and the ecology of the Cascades and the Sierra Nevada.

Special Status Wildlife Species (pg 5-16)

Table 5-5. USFS Management Actions for Special-Status Wildlife Species, OSV Program

Special-Status Species[1]	Location and Habitat	USFS Management Action
northern goshawk (FSS, CSSC)	Mature coniferous forests and riparian aspen groves serve as both nesting and foraging habitat. Nests in a wide variety of forest types including deciduous, coniferous, and mixed forests across all national forests.	All OSV Program national forests: Monitoring of northern goshawk Protected Activity Centers (PACs). Limited operating period (LOP) on groomed trails within 1/4 mile of nest sites after February 15 where there is documented evidence of disturbance from existing recreation activities.
northern spotted owl (FT, CSSC)	Inhabits old growth forests in the northern part of its range (Canada to southern Oregon) and landscapes with a mix of old and younger forest types in the southern part of its range (Klamath region and California).	Klamath, Modoc, and Shasta-Trinity National Forests: Monitoring of northern spotted owl PACs. LOP on groomed trails within 1/4 mile of nest sites after February 15 where there is documented evidence of disturbance from existing recreation activities.
California spotted owl (FSS, CSSC)	Resides in dense, old growth, multi-layered mixed conifer, redwood, and Douglas-fir habitats, from sea level up to approximately 7,600 feet.	Eldorado, Lassen, Plumas, Sequoia, Sierra, Stanislaus, and Tahoe National Forests: Forest monitoring of California spotted owl PACs. LOP on groomed trails within 1/4 mile of nest sites after March 1 where there is documented evidence of disturbance from existing recreation activities.

Comment [LNF 16]: **Northern goshawk-**
Evidence of disturbance from recreation activities will likely depend on the results of Regional Focus studies for this species.

California spotted owl
Evidence of disturbance from recreation activities will likely depend on the results of Regional Focus studies for this species. Typical presence/absence monitoring cannot provide substantive evidence of site disturbance from OSV activities.

9.0 PROJECT ALTERNATIVES (pg 9-1)

9.4 Redirection of Grooming Funds

Comment [LNF 17]: This option would allow the moderate level of groomed trail use while still addressing the problems with "required" unfunded resource monitoring.

The 2002 BCP allocates up to one million dollars from the OHV Trust Fund for winter trail maintenance, including grooming, plowing, and restroom service, that directly supports OHV winter recreation. None of the OSV Program funds are used to provide law enforcement, public education, or biotic resource inventories and monitoring, all of which are identified in the EIR analysis as needed mitigation and could require additional funding (Land Use Section 3.3.4, Biology Section 5.3.4, and Recreation Section 8.3.4). These three responsibilities are primarily funded and staffed as needed by the USFS (Project Description, Section 2.5) with some periodic funding provided by the OHV Trust Fund through the Grants Program. Under the Redirection of Grooming Funds Alternative, a portion of funds allocated by the 2002 BCP for grooming (the primary funded activity of the OSV Program) would be redirected to fund the needed law enforcement, public outreach, and biotic resource monitoring measures specified in the EIR while keeping total funding for the OSV Program under the 2002 BCP million dollar cap. This alternative would have the benefit of securing funds for EIR mitigation within the 2002 BCP budget cap. However, given that resource monitoring, public education, and law enforcement activities are not specific activities authorized for funding under the BCP, an amendment would be required for the OSV Program to fund these activities through the BCP funding allocation. Under this project alternative, grooming frequency throughout the Project Area would be reduced to free up funding for law enforcement and resource monitoring. Plowing would remain unchanged in order to preserve access to all trailheads. This alternative would not necessarily stop grooming but would substantially reduce the frequency of grooming, leaving trail conditions rough. These conditions could result in reduced OSV use on the project trails throughout the Project Area.

9.5 Environmentally Superior Alternative

CEQA requires that the EIR analysis of project alternatives identify an “environmentally superior” alternative. If the environmentally superior alternative is the “No Project” alternative, the EIR shall also identify an environmentally superior alternative from among the other alternatives. Funding groomed trails in restricted riding areas only would limit OSV use associated with the OSV Program to groomed trails, which are established travel routes with a paved or dirt and gravel road base. This substantially reduces the potential for impact to biological resources and inadvertent wilderness trespass associated with the OSV Program as a whole. Off-trail OSV use would continue in national forests but likely at reduced levels and therefore environmental effects from OSV use in these areas would likely be reduced. For these reasons, Funding Restricted Riding Areas Only is considered the environmentally superior alternative that can partially meet the project objectives.

Comment [LNF 18]: This is a very subjective statement. A financial analysis is needed to show
1) How much funding of law enforcement and resource monitoring would reduce grooming activity? and
2) What level of decrease in grooming activity would lead to a substantial reduction OSV use?

The statement appears to be an opinion unsubstantiated with any data.

Recommended rephrased: “**This alternative would not necessarily stop grooming, but may result in a reduction in grooming frequency, which could leave trail conditions rough**”.

Comment [LNF 19]: From a biological resources perspective it is agreed that the “Funding Restricted Riding Areas Only” alternative is the Environmentally Superior Alternate. Also, that it would discourage some public use.

This alternative would require a substantial increase in Law Enforcement and a Forest Plan amendment.

Over Snow Vehicle (OSV) Snow Program Monitoring Report

Per

EIR Data Request Related to the OSV Snow Program

Lassen National Forest

Pacific Southwest Region 5

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Introduction

Under the 2009 Collection Agreement (10-CO-11050650-008) the US Forest Service, in partnership with the State, manages snow parks and the associated Over Snow Vehicle (OSV) route systems at 5 locations around Lassen National Forest (NF). The Collection Agreement (CO) establishes the terms of Snow Program management and allocates funds for management of Ashpan, Bogard, Fredonyer, Morgan Summit and Swain Mountain Snow Parks and their designated OSV route systems through the Green Sticker Fee program. The CO also allocates money for conducting monitoring on the Forest related to the Snow Management Program. According to the CO and the 2008 Cost Sharing Agreement Initial Study Negative Declaration (TRA Environmental Sciences Inc. 2008) the Forest Service has responsibility for conducting ongoing monitoring of botany, wildlife and soil resources in order to modify management actions to minimize any negative effects resulting from the agency's winter Snow Grooming Program.

According to the OSV Snow Program Challenge Cost Share Agreement EIR Data Request, each Forest which receives funding needs to provide information relevant to their program. This report covers the following issues specific to wildlife and botanical resources:

1) Monitoring checklist data sheets filled out during the 2009/2010 winter season.

9) Identify the GIS staff that can be contacted to provide GIS data of trail routes and of known biological resources in the NF near project trails.

10) Provide spotted owl and Northern goshawk studies which are to be completed in 2009.

11) What Management policies/ Management Actions are in place by USFS which govern OSV use and minimize environmental impacts?

Biologists on Lassen NF monitor specific wildlife and botanical resources (Table 1) relative to their proximity, or sensitivity to designated OSV routes. The Forest Service also initiated focused studies on a subset of these species, Northern goshawks (Plumas NF) and Northern spotted owls (Shasta-Trinity and Mendocino National Forests) to evaluate direct effects of interactions with OSVs during their breeding timeframes. The Regional Forester also directed each Forest, with an OSV program, to monitor for special status species in order to protect biological resources. Implementation of the proposed management actions is intended to insure that the effects of the Snow Program on special status species will continue at existing baseline levels and not result in any new effect.

1) Monitoring checklist data sheets filled out during the 2009/2010 winter season.

Table 1a. Management Actions for OSV Snow Program on Lassen NF – Wildlife Species

Special Status Species	Management Concern?	National Forest Management Action
Wildlife Species		
Northern goshawk (FFS, CSSC)	Yes	Continue Forest monitoring of goshawk Protected Activity Centers (PACs). Determine if a limited operating period within ¼ mile of PACs after February 15 needs to be implemented.
California spotted owl (FFS, CSSC)	Yes	Continue Forest monitoring of goshawk Protected Activity Centers (PACs). Determine if a limited operating period within ¼ mile of PACs after March 1 needs to be implemented.
Northern spotted owl (FT)	No	Sub-species is not present on Lassen NF in proximity of OSV routes, so it is not a management concern.
Willow flycatcher (FFS, SE)	No	None. Species is not present during the OSV operating period.
American marten (FFS)	No	Ongoing monitoring of this species is conducted on the forest.
Sierra Nevada red fox (FFS, ST)	No	None. OSV impact undetermined.
Pacific fisher (FFS, FC, CSSC)	No	No breeding activity documented on Lassen NF. Ongoing monitoring is underway to determine if fishers are breeding on National Forest land.
California wolverine (FFS, ST)	No	No sightings on Lassen NF.

Table 1b. Management Actions for OSV Snow Program on Lassen NF – Plant Species

Special Status Species	Management Concern?	National Forest Management Action
Plant species		
Slender orcutt grass (FT, SE)	No	Previous monitoring has indicated no impacts from OSV use.
Barron’s buckwheat (FSS)	No	Previous monitoring has indicated no impacts from OSV use.
Columbia yellow cress (FFS)	No	Previous monitoring has indicated no impacts from OSV use.

Wildlife Species

Northern goshawks *(Accipiter gentilis)*

Breeding activity for Northern goshawks can be broken down into 5 general activity stages: courtship (pre-breeding), laying, incubation, nestling and fledgling stages. The courtship stage typically begins in mid-February or early March and extends through the formation of breeding pairs, nest building, and copulation. Egg laying and incubation overlap in goshawks, with eggs being laid every 3 days, and incubation beginning with the laying of the second egg. The onset of the incubation in the Lassen NF region (southern Cascades/ northern Sierra Nevada) occurs between April 10 and May 15 (USFS 2000), though it can be delayed by up to a month with cool or damp spring weather (Younk and Bechard 1994), and lasts 28-38 days. Nestlings typically fledge at 35-42 days old (Squires and Reynolds 1997).

Northern goshawk require a degree of spatial isolation in order to provide sufficient resources for successful reproduction, and have habitat preferences for mature to late-successional forests. Goshawks typically utilize multiple nesting sites within a nesting territory, which can sometimes be located more than ½ mile apart (Woodbridge and Detrich 1994). Because of this behavior, locating active nesting locations and verifying occupancy of a territory can be difficult using only irregular broadcast surveys or searches for active nests. As a result, verification of an inactive stand requires multiple visits in subsequent years.

California Spotted owl (*Strix occidentalis occidentalis)*

Breeding activity for spotted owls is broken into 5 stages (pre-laying, laying, incubation, nestling, and fledging) and roughly parallels the time frame of N. goshawks. Pre-laying behavior in spotted owls begins in March and lasts for 3 weeks prior to the laying of the first egg. Egg-laying starts from April 11-25 and can take 1-6 days to complete. Incubation starts with laying of the first egg and lasts 28-32 days.

Nestlings fledge after 34-36 days around June 12-26 (Forsman et. al. 1984). Much of the data available for spotted owl breeding phenology is derived from the Northern spotted owl subspecies.

The California spotted owl like Northern spotted owls, require large areas of habitat and are typically found only in late-successional or old growth forests. Forsman *et al . (1984)* found that Northern spotted owl territories in the Oregon Cascades averaged between 549 and 3,380 ha in size, and that adult owls may not nest every year depending on the availability of resources. The combination of these factors makes locating nesting locations difficult.

Northern Spotted owl *(Strix occidentalis caurina)*

On the Lassen NF, this sub-species does not occur within the vicinity of any OSV routes so it is not a concern in relation to this recreational activity.

Willow flycatcher *(Empidonax traillii*)

Willow flycatchers occur in some mountain meadows within Lassen NF. However, they are summer residents and are not present on the Forest during the OSV-use period. They are not considered a management concern in regards to the Snow Management Program.

American marten (*Martes americana*)

American marten are present within Lassen NF. A previous study (Zielinski *et. al.* 2007) was completed, investigating the response of marten to OHV and OSV related disturbance in the Sierra Nevada Mountains in California. The study was inconclusive in demonstrating any negative effect of OHV/OSV use on marten reproduction and survival.

Sierra Nevada red fox (*Vulpes vulpes necator*)

There is an endemic population of Sierra Nevada red fox on Lassen NF. No studies have been conducted on OSV use related to this population at the current time.

Pacific fisher *(Martes pennanti)*

The Pacific fisher has been recently reintroduced to areas near on the Lassen NF. While no animals have been documented to be breeding on Lassen NF, radio-collared animals have been located moving onto the forest from adjacent areas. They are considered an experimental population and are currently being monitored by CDFG. None of these fisher detections are near existing OSV routes therefore, no studies are currently planned examining OSV impacts on the species.

Plant Species

Slender orcutt grass *(Orcuttia tenuis)*

Slender orcutt grass is associated with vernal pools which in proximity to OSV free roam meadow areas. Previous monitoring was conducted in relation to OSV routes on the forest. No impact was found related to OSV use.

Barron's buckwheat *(Eriogonum spectabile)*

Barron's buckwheat is associated with several OSV free roam meadow areas. Previous monitoring was conducted in relation to OSV routes on the forest. No impact was found related to OSV use.

Columbia yellow cress *(Rorippa columbiae)*

Columbia yellow cress is also associated with several OSV free roam meadow areas. Previous monitoring was conducted in relation to OSV routes on the forest. No impact was found related to OSV use.

Biologists on Lassen NF monitor specific wildlife and botanical resources relative to their proximity, or sensitivity to designated OSV routes. The PSW Regional Office has also initiated focused studies on a subset of these species, Northern goshawks (Plumas NF) and Northern spotted owls (Shasta-Trinity and Mendocino National Forests) to evaluate direct effects of interactions with OSVs during their breeding timeframes. Further direction was issued directing Forests to monitor for special status species in order to protect biological resources. Implementation of the proposed Management Actions is intended to insure that the effects of the Snow Program on special status species will continue at existing baseline levels and not result in any new effect.

9) Identify the GIS staff that can be contacted to provide GIS data of trail routes and of known biological resources in the NF near project trails.

GIS Specialists Matt House or Priscilla Peterson can be contacted for current Forest GIS layers (roads, trails etc.). Wildlife Biologist Patrick Lieske can be contacted concerning GIS data or analysis of biological resources represented in this report.

10) Provide Northern goshawk and spotted owl studies which are to be completed in 2010.

Avian Monitoring

Northern goshawk

Northern goshawks (NGO) have a breeding season which overlaps with OSV use in the southern Cascade/ northern Sierra Nevada areas. This period overlaps during the courtship/pre-laying, laying and into the early phases of the Incubation stage according to the snow grooming history reports and personal observations of continued OSV activity beyond the end of the grooming season.

Monitoring of NGO Protected Activity Centers (PAC, see glossary definition) was completed using a combination of Aural Broadcast Surveys and brief stand visits to locate active nests. Visits to NGO PACs for broadcast surveys or nest searches are made during the nestling and fledgling stages (June-August) when the birds are the most vocal. Goshawk monitoring has previously been conducted on Ranger Districts either by agency biologists or contractors. PACs are visited on an irregular basis, depending on district management. This has led to a patchy data record concerning current status of NGO PACs. Monitoring efforts are documented in tables below by ranger district (Tables 3-5).

CA spotted owl

California spotted owls (CSO) have a breeding season which overlaps with OSV use in the southern Cascade/ northern Sierra Nevada areas. This period overlaps during the courtship/pre-laying, laying and into the early phases of the Incubation stage according to the snow grooming history reports and personal observations of continued OSV activity beyond the end of the grooming season.

Monitoring of CSO Protected Activity Centers (PAC, see glossary definition) has been completed using established call stations which are periodically revisited. CSO PACs are visited between April and August to survey established call stations for breeding birds, or to conduct nest searches in areas where birds were previously detected. Monitoring work has been conducted by district biologists, contractors and Southwest Research Station biologists. CSO PACs are visited on a more regular basis in accordance with regional monitoring initiatives. Data records for CSO are kept on the USFS corporate website (NRIS) and are currently up to date for all data collected in 2009. Monitoring efforts are documented in tables below by ranger district (Tables 6-8).

Table 2. Almanor RD NOGO PACs within 400m of groomed OSV routes, 2006-10

PAC Name	OSV Snow Park/ Route Access	Current Status	Notes
Rock Creek 1	Swain Mountain	Unknown	Surveyed in 2010. No detections.
Rock Creek 2	Swain Mountain	Unknown	Surveyed in 2010. No detections.
The Hole	Swain Mountain	Unknown	Brief searches conduct 2007-09, no birds or nests found. Last observation made 2005.
North Fork Antelope Creek	Morgan Summit	Active	Surveyed in 2007, 2008 and 2009. Nests verified each year.
Hole in the Ground	Morgan Summit	Unknown	Entire PAC surveyed in 2010. No detections.
Mill Creek	Morgan Summit	Unknown	Brief searches conduct 2007-09, no birds or nests found. Adult bird observed in 2005.
Summit Creek	Morgan Summit	Active	Surveyed in 2007, 2008 and 2009. Nests verified each year.

Table 3. Eagle Lake RD NOGO PACs within 400m of groomed OSV routes, 2006-10

PAC Name	OSV Snow Park/ Route Access	Current Status	Notes
Crater Mountain	Bogard	Abandoned	Abandoned after years of inactivity and after a nest was found at Caldera.
Caldera	Bogard	Unknown	Nest was found in 2004. Believed to still be active by district biologist and will be surveyed in 2010.
West Pegleg	A21 Access	Active	Surveyed in 2010. No detections. Obs. In 2006.
North Pegleg Mountain	A21 Access	Active?	Surveyed entire PAC in 2010. Silent detection of a goshawk along NE edge of the PAC.
Crazy Harry Gulch	Fredonyer	Unknown	Surveyed around the previous observation location, no detections.
Fredonyer Pass	Fredonyer	Unknown	Surveyed around the previous observation location, no detections.
Roxie	Fredonyer	Active	Territorial male goshawk observed in 2010.
Willard Creek	Fredonyer	Unknown	Nest found in 1988. Stand was affected by insect caused mortality in the 1990s. May be abandoned.
Willard Creek E. Fork	Fredonyer	Unknown	Surveyed in 2010. No detections.

Table 4. Hat Creek RD NOGO PACs within 400m of groomed OSV routes, 2006-10

PAC Name	OSV Snow Park/ Route Access	Current Status	Notes
Huckleberry	Ashpan	Active	Surveyed in 2009, nest found.
Bunchgrass Valley	Ashpan	Unknown	Not surveyed in 2006-09. Last observation in 2003. Survey in 2011.
Battle Springs	Ashpan	Unknown	Not surveyed in 2006-09. Last observation in 2003. Survey in 2011.
Red Lake	Ashpan	Active	Group of NGO observed in 2006.
Grayback	Ashpan	Unknown	Not surveyed in 2006-09. Last observation in 2004. Survey in 2011.
Ashpan	Ashpan	Active	Surveyed in 2009, nest found.
North Battle Creek	Ashpan	Active	Last nest found in 2006. Not surveyed since 2006.

[1] PACs were considered "Active" if birds or nests were found within the past 5 years, "Unknown" if no birds were detected in the last 5 years, or "Abandoned" if no activity has been detected in over 20 years.

Table 5. Almanor RD Spotted Owl PACs within 400m of groomed OSV routes, 2006-10.

Site Name	OSV Snow Park/ Route Access	Current Status	Action
cso PAC TEH0006 - Cold Creek	Morgan Summit	Active	Nest found in 2007.
cso PAC TEH0008 - Hole in Ground	Morgan Summit	Active	Nests found in 2004 and 2007.
cso PAC TEH0009 - Christie Hill	Morgan Summit	Active	Birds detected during 2007 surveys.
cso PAC TEH0021 - Mill Creek	Morgan Summit	Active	Birds detected during 2007 surveys.
cso PAC TEH0067 - Morgan Mtn.	Morgan Summit	Unknown	Surveyed in 2007. No nests or detections since nest found 370m NE of PAC in 2002.
cso PAC TEH0068 - Big Bend	Morgan Summit	Unknown	Surveyed in 2007. No nests or detections since before 2006.
cso PAC TEH0080 - Battle Creek	Morgan Summit	Unknown	Surveyed in 2007. No detections or nests since 2000.
cso PAC TEH0081 - Turner Mtn.	Morgan Summit	Active	Birds detected during 2007 surveys.
cso PAC TEHNEW2 - Monterey Point	Morgan Summit	Unknown	Surveyed in 2007. Nest found just outside PAC in 2004.
cso PAC LAS0043 - Jennie Creek	Swain Mnt.	Unknown	Bird detected about 700m NNW from the PAC in 2007, just past OSV route. Last nest within PAC found in 2000.
cso PAC PLU0001 - Jennie Mt.	Swain Mnt.	Active	Birds detected during 2007 surveys.

cso PAC PLU0052 - Last Chance Mud	Swain Mnt.	Active	Birds detected during 2007 surveys.
cso PAC PLU0053 - Mud Creek	Swain Mnt.	Unknown	No recent detections. No nests found since early 1990s.
cso PAC PLU0054 - Last Chance Creek	Swain Mnt.	Unknown	Bird detected about 400m E of the PAC in 2007. Last nest found in 2004.
cso PAC PLU0057- Star Butte	Swain Mnt.	Unknown	No detections since before 2006. Last nest found in 1992.

Table 6. Eagle Lake RD Spotted Owl PACs within 400m of groomed OSV routes, 2006-10.

Site Name	OSV Snow Park/ Route Access	Current Status	Action
cso PAC LAS0003 - Pine Cr.	Fredonyer	Active	Birds detected in HRCA and around PAC in 2007.
cso PAC LAS0006 - Hamilton Mt.	Fredonyer	Active	Birds detected, nest found in 2007.
cso PAC LAS0009 - Mt. Meadows Cr. E	Fredonyer	Active	Birds detected during 2007 surveys. Nests found in early ‘90s.
cso PAC LAS0012 - Coyote Peak	Fredonyer	Unknown	No detections/ nests since 1990.
cso PAC LAS0016 - Crazy Harry Gulch	Fredonyer	Active	Birds detected in 2007 surveys. Last nest found in 2005.
cso PAC LAS0018 - Pegleg	Fredonyer	Active	Birds detected during 2007 surveys. Nests found in 2003, 2004.
cso PAC LAS0025 - Fredonyer Pass	Fredonyer	Active	Birds detected during 2007 surveys. Reproducing.
cso PAC LAS0027 - Willard Cr. S	Fredonyer	Active	Birds detected / nest found in HRCA in 2007. Nest found in PAC in 2006.
cso PAC LAS0031 - West Branch Pine Cr.	Fredonyer	Unknown	No birds detected since before 2006.

Table 7. Hat Creek RD spotted owl PACs within 400m of groomed OSV routes, 2006-10.

Site Name	OSV Snow Park/ Route Access	Status	Action
cso PAC SHA0011 (HC10)	Ashpan	Active	Reproducing birds documented in 2009.
cso PAC SHA0014 (HC13)	Ashpan	Unknown	No observations in 2007 to 2009.
cso PAC SHA0015 (HC11)	Ashpan	Active	Bird observed in 2009.
cso PAC SHAxxxA (HC15)	Ashpan	Unknown	No observations since before 2006. Adjacent to an active area.
cso PAC SHAxxxB (HC16)	Ashpan	Unknown	No observations in 2007 to 2009.

[1] PACs were considered "Active" if birds or nests were found within the past 5 years, "Unknown" if no birds were detected in the last 5 years, or "Abandoned" if no activity has been detected in over 20 years.

Lassen NF -Snow Grooming History

Snow grooming activities are typically initiated around December 25 and continue to a variable end date the following calendar year. The OSV trail system is managed according to an annual Forest Order (# 06-08-09) that takes effect on December 25 and expires on March 31. The actual completion date of snow grooming activities (Table 8) is determined based on existing snow levels across the forest and fallen within a 30-day window for the past 5 years for which data exists (3/9-4/8). The average completion date for grooming activities was March 21 based on the existing data.

Inspections conducted of the Lassen NF snow parks on April 17 and May 1, 2010 indicated that OSV user activity extends beyond the March 31 termination date closing roads for exclusive OSV use. OSV use was assumed to be very low (< 10 riders per site/ per day on a weekend), varying depending on specific snow depths and daily temperatures.

Table 8. Average calendar date for completion was determined based on the numeric calendar dates for the past 5 years of data

Year	Last Date of Grooming	Days in the Year	Day of Year (Numeric)
2010	3/22	365	81
2009	3/18	366	77
2008	3/17	365	77
2007	3/9	365	68
2006	4/8	365	98
Average Finish Day	80		
Average Finish Date	3/21		

Interaction between Avian Activity and Snow Grooming

Based on established activity periods for goshawks and California spotted owls there are periods of overlap between OSV activity and early goshawk and spotted owl breeding seasons (Fig. 1). Surveys of Forest Snow Parks and designated OSV route access points has indicated that low levels of OSV use (< 10 vehicles per site/day) persist beyond the end of the road closure for OSV only use on March 31. OSV use was documented until the end of April, at which point snow levels no longer allow continued use of designated OSV routes. For purposes of analysis, April 30 was used as a cut-off date for the maximum period of interaction (NGO: Feb 15- Sep 15, 74-75 days, CSO: Mar 1- Aug 31, 61-62 days). We focused specifically on both NGO and CSO PACs that are adjacent to these designated OSV routes. PACs were selected for monitoring and analysis if they fell within a 400m (1/4 mile) buffer of the OSV routes.

OSV User Activity

The National Vehicle Use Monitoring Program (NVUM) released reports for the US Forest Service, Southwest Region in 2000 and 2005. The reports do not specifically address OSV use in a fashion to provide reliable statistics for the snow parks managed by Lassen National Forest. Interpretation of the reports indicated that Lassen NF likely receives 10000-20000 yearly visitors distributed across the forest depending on local snow levels at the Snow Parks (Note: This is a crude estimate, and the standard error could not be determined).

Lassen National Forest has 5 designated OSV route systems which the Forest Service is responsible for maintaining. Ashpan Snow Park is located on the Hat Creek Ranger District off of Hwy 44 (Fig. 2). Morgan Summit Snow park (Fig. 3) and Bogard Snow park (Fig. 4) are located on the Almanor Ranger District, off of Hwy. 36 and 44 respectively. Swain Mountain Snow park (Fig. 5) and Fredonyer Snow park (Fig. 6) are located on the Eagle Lake Ranger Districts off Hwy A-21 and Hwy 36.

Results

NGO

Lassen National Forest has 174 NGO PACs, of which 33 (19%) are within 400m of designated OSV routes. Twenty-three NGO PACs fell within the scope of the GIS analysis conducted. The other 10 PACs were on the Almanor RD and fall along the Jonesville Snow Park OSV routes which is managed by the Forest Service aside from the existing Collection Agreement with State of California.

CSO

Lassen National Forest has 118 CSO PACs, of which 42 (36%) are within 400m of designated OSV routes. Only 29 of the CSO PACs were within the scope of the GIS analysis conducted. The other 13 PACs were on the Almanor RD and fall along the Jonesville Snow Park OSV routes which is managed by the Forest Service aside from the existing Collection Agreement with State of California.

GIS proximity analysis was completed on NGO PACs (Table 9) and CSO PACs (Table 10) using ArcGIS (ESRI, Version 9.3.1) to evaluate whether the distance of a PAC from a snow park is a predictor for the status of the PAC. No relationship was apparent between a PAC’s distance from a snow park and whether it has been recently occupied.

Table 9. Distance to NGO PAC centroid from Snow Park access as determined by Proximity Analysis.

Site Name	OSV Snow Park/ Route Access	Current Status	Distance from Snow Park to PAC centroid in meters
Fredonyer Pass	Fredonyer	Unknown	500
Summit Creek	Morgan Summit	Active	1130
Ashpan	Ashpan	Active	2054
Crazy Harry Gulch	Fredonyer	Unknown	2745
Mill Creek	Morgan Summit	Unknown	2860
Crater Mountain	Bogard	Abandoned	3480
Caldera	Bogard	Unknown	3500
Grayback	Ashpan	Unknown	3915
Bunchgrass Valley	Ashpan	Unknown	4060
Roxie	Fredonyer	Unknown	4910
Red Lake	Ashpan	Unknown	5500
Hole in the Ground	Morgan Summit	Unknown	5920
The Hole	Swain Mountain	Unknown	6680
Battle Springs	Ashpan	Unknown	8050
West Pegleg	Swain Mountain	Unknown	8830
North Fork Antelope Creek	Morgan Summit	Active	9300
Willard Creek E. Fork	Fredonyer	Unknown	9340
Willard Creek SOHA	Fredonyer	Unknown	9370
Rock Creek 1	Swain Mountain	Unknown	9585
North Battle Creek	Ashpan	Unknown	9810
North Pegleg Mountain	Swain Mountain	Unknown	9815
Rock Creek 2	Swain Mountain	Unknown	9970
Huckleberry	Ashpan	Active	11600

Table 10. Distance to CSO PAC centroid from Snow Park access as determined by Proximity Analysis.

Site Name	OSV Snow Park/ Route Access	Current Status	Distance from Snow Park to PAC centroid in meters
cso PAC LAS0025 - Fredonyer Pass	Fredonyer	Active	740
cso PAC SHAxxxA (HC15)	Ashpan	Unknown	1400
cso PAC TEH0009 - Christie Hill	Morgan Summit	Active	2020
cso PAC SHA0015 (HC11)	Ashpan	Active	2140
cso PAC TEH0067 - Morgan Mtn. SOHA	Morgan Summit	Unknown	2700
cso PAC LAS0016 - Crazy Harry Gulch	Fredonyer	Active	2920
cso PAC LAS0006 - Hamilton Mt.	Fredonyer	Active	4075
cso PAC LAS0003 - Pine Cr.	Bogard	Active	4750
cso PAC LAS0012 - Coyote Peak	Fredonyer	Unknown	5800
cso PAC LAS0043 - Jennie Creek	Swain Mnt.	Unknown	6150
cso PAC TEH0008 - Hole in Ground SOHA	Morgan Summit	Active	6340
cso PAC PLU0001 - Jennie Mt. SOHA	Swain Mnt.	Active	6600
cso PAC PLU0057- Star Butte SOHA	Swain Mnt.	Unknown	6630
cso PAC SHA0011 (HC10)	Ashpan	Active	7190
cso PAC SHA0014 (HC13)	Ashpan	Unknown	7960
cso PAC TEH0006 - Cold Creek	Morgan Summit	Active	8000
cso PAC SHAxxxB (HC16)	Ashpan	Unknown	8000
cso PAC TEH0021 - Mill Creek	Morgan Summit	Active	8740
cso PAC LAS0031 - West Branch Pine Cr.	Fredonyer	Unknown	9270
cso PAC LAS0027 - Willard Cr. S	Fredonyer	Active	9290
cso PAC LAS0009 - Mt. Meadows Cr. E	Fredonyer	Active	9790
cso PAC LAS0018 - Pegleg	Fredonyer	Active	10150
cso PAC TEH0080 - Battle Creek	Morgan Summit	Unknown	10400
cso PAC TEH0081 - Turner Mtn.	Morgan Summit	Active	10570
cso PAC TEH0068 - Big Bend SOHA	Morgan Summit	Unknown	10590
cso PAC TEHNEW2 - Monterey Point	Morgan Summit	Unknown	12340
cso PAC PLU0053 - Mud Creek SOHA	Swain Mnt.	Unknown	13740
cso PAC PLU0054 - Last Chance Creek	Swain Mnt.	Unknown	15430
cso PAC PLU0052 - Last Chance Mud	Swain Mnt.	Active	15790

Discussion

Compilation of existing monitoring data for NGO showed that data gaps exist for some PACs which have not been recently surveyed. Supplemental monitoring was conducted during the summer of 2010 (June-August). The objective of this monitoring was to survey all PACs within 400m of designated OSV routes which have not been surveyed in the past 5 years. Three PACs remain to be surveyed in 2011.

11) What Management policies/ Management Actions are in place by USFS which govern OSV use and minimize environmental impacts?

The Forest Service has initiated focus studies examining responses of Northern goshawks and California spotted owls to OSV disturbance. These studies will help inform managers of specific relationships and responses of these species to noise and activity-related disturbance which may affect breeding activity.

Managers have the option of initiating a Limited Operating Period (LOP, see Glossary) which would limit access to OSV routes during the breeding seasons for NGO and CSO. This option has not been used pending further monitoring of the PACs to determine if a cause/effect relationship exists. Another study (Zielinski *et. al.* 2007) examining relationships between American marten and OHV/OSV disturbance was inconclusive in demonstrating whether the motorized vehicles impacted the animals breeding activity.

Snow Management Program

Based on the overlap with the breeding seasons for both NGO and CSO, it is recommended that snow grooming activities should not be allowed to extend beyond the Forest Order expiration date of March 31, as occurred during the 2006 season.

Literature Cited

Forsman, Eric D.; Meslow, E. Charles; Wight, Howard M. 1984. Distribution and biology of the spotted owl in Oregon. Wildlife Monographs 87:1-64.

Squires, J.R., and R.T. Reynolds. 1997. Northern Goshawk (ACCIPITER GENTILIS). In A. Poole and F. Gill, editors, The Birds of North America, No. 298. Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, DC. 32 pp.

TRA Environmental Sciences Inc. 2008. Over Snow Vehicle Snow Program Cost Sharing Agreements Initial Study/Negative Declaration. Report submitted to State of California, Department of Parks and Recreation, Off-Highway Motor Vehicle Recreation (OHMVR) Division.

US Forest Service. 2000. Survey methodology for northern goshawks in the Pacific Southwest region, US Forest Service, Unpublished report. 18pp.

Verner J., R. J. Gutiérrez, and G. I. Gould, Jr. 1992. The California Spotted Owl: General Biology and Ecological Relations. Chapter 4. USDA Forest Service Gen. Tech. Rep. PSW-GTR-133.

Woodbridge, B. and P. J. Detrich. 1994. Territory Occupancy and Habitat Patch Size of Northern Goshawks in the Southern Cascades of California. Studies in Avian Biology 16: 83-87.

Younk, J. V. and M. J. Bechard. 1994. Breeding ecology of the northern goshawk in high-elevation aspen forests of northern Nevada. Studies in Avian Biology 16:119-121.

Zielinski, W. J., K. M. Slauson and A. E. Bowles. 2007. The Effect of Off-Highway Vehicle Use on the American Marten in California, USA. Final report to the U. S. Department of Agriculture Forest Service, Pacific Southwest Region, and California Department of Parks and Recreation, Off-Highway Motor Vehicle Division. Arcata, CA: US Dept of Agriculture, Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory. 30pp.

Glossary

CSO: California spotted owl.

LOP: Limited operating period, An LOP is a management action taken to limit the disturbance of a biological resource during a key period of concern.

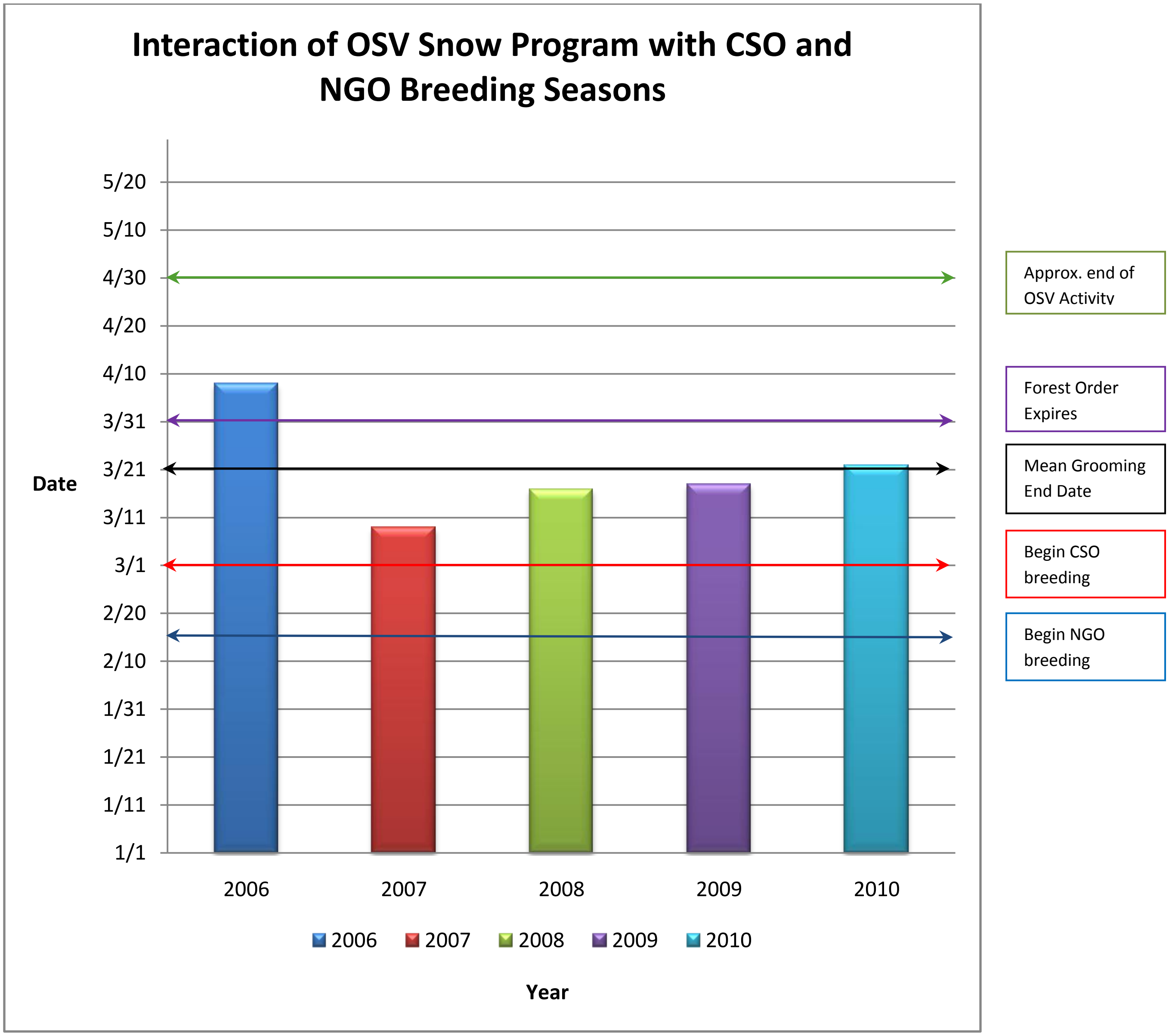
NGO: Northern goshawk.

OHV: (Off-Highway Vehicle) Includes both highway legal vehicles driven off-road and All-Terrain Vehicles

OSV: (Over Snow Vehicle) Snowmobiles, snow grooming machinery.

PAC: (Protected Activity Center) An area of habitat used by both NGO and CSO which encompasses the core of their breeding territory. They are delineated to include known and suspected nest stands, and encompass the best available 200 (NGO) or 300 (CSO) acres of habitat in the largest contiguous area possible (for NGO) or as compact a unit as possible (for CSO).

Figure 1. Snow grooming completion dates for the past 5 years, 2006-2010, and how they interact with CSO and NGO breeding seasons.



[1] Breeding initiation dates for CSO and NGO were approximated from information available in the literature due knowledge gaps concerning local populations.

[2] A reoccurring Annual Forest Order closes designated forest roads for OSV-only traffic from 12/25-3/31 each year.

Figure 2. Hat Creek RD- CSO and NGO PACs within 400m of Ashpan Snow Park OSV routes, Lassen NF.

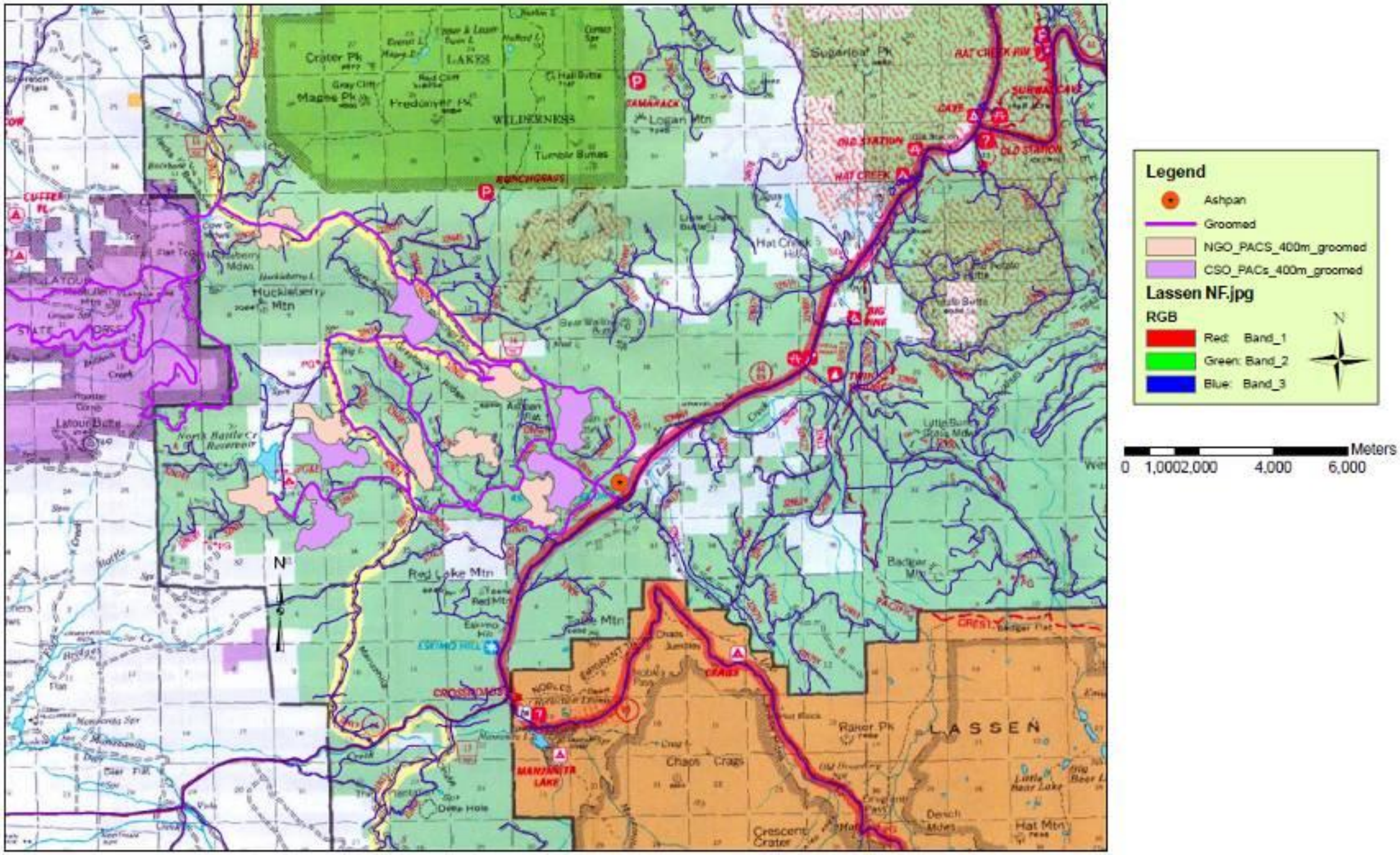


Figure 3. Almanor RD- CSO and NGO PACs within 400m of Morgan Summit Snow Park OSV routes, Lassen NF.

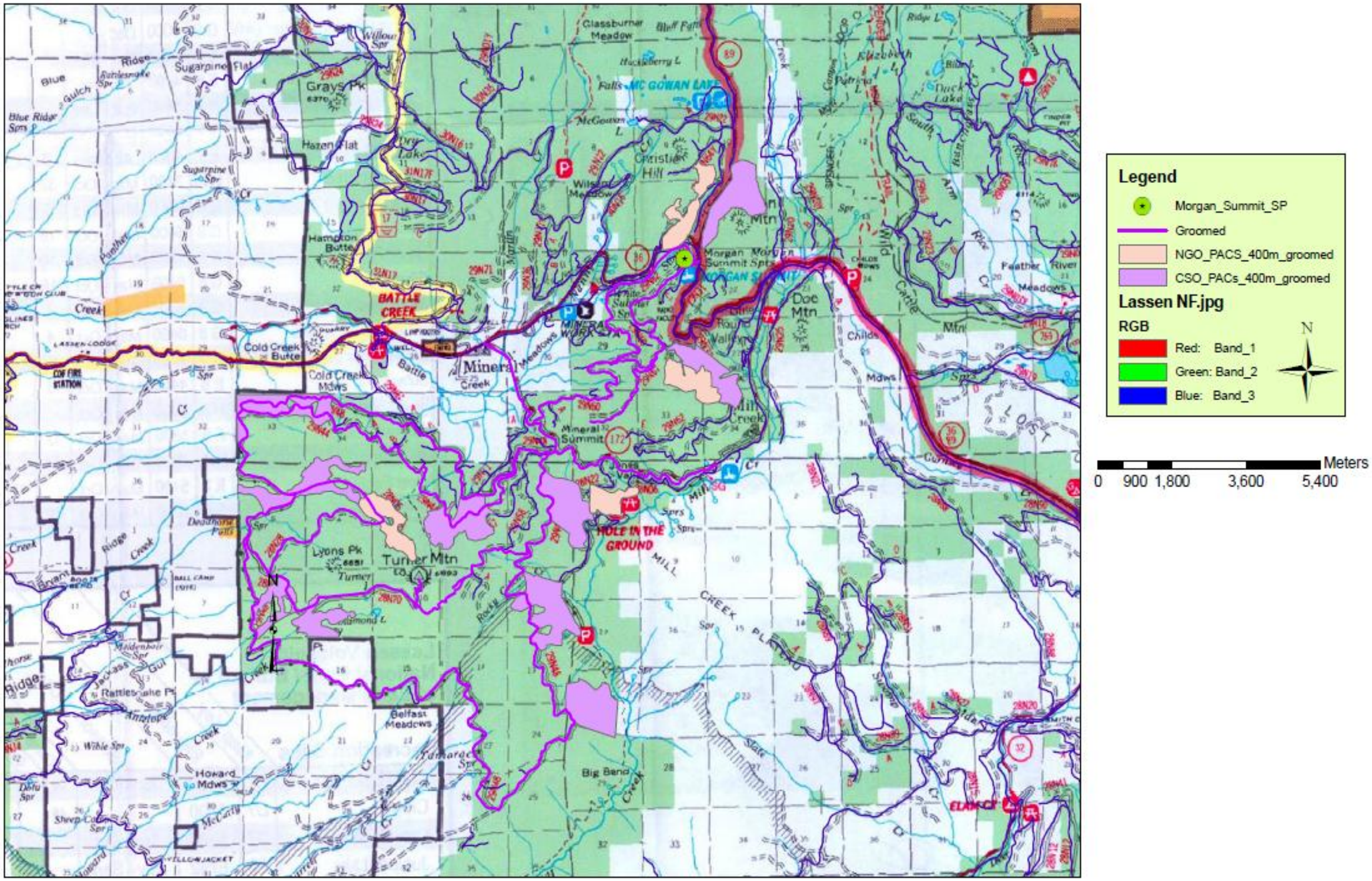


Figure 4. Almanor RD- CSO and NGO PACs within 400m of Bogard Snow Park OSV routes, Lassen NF.

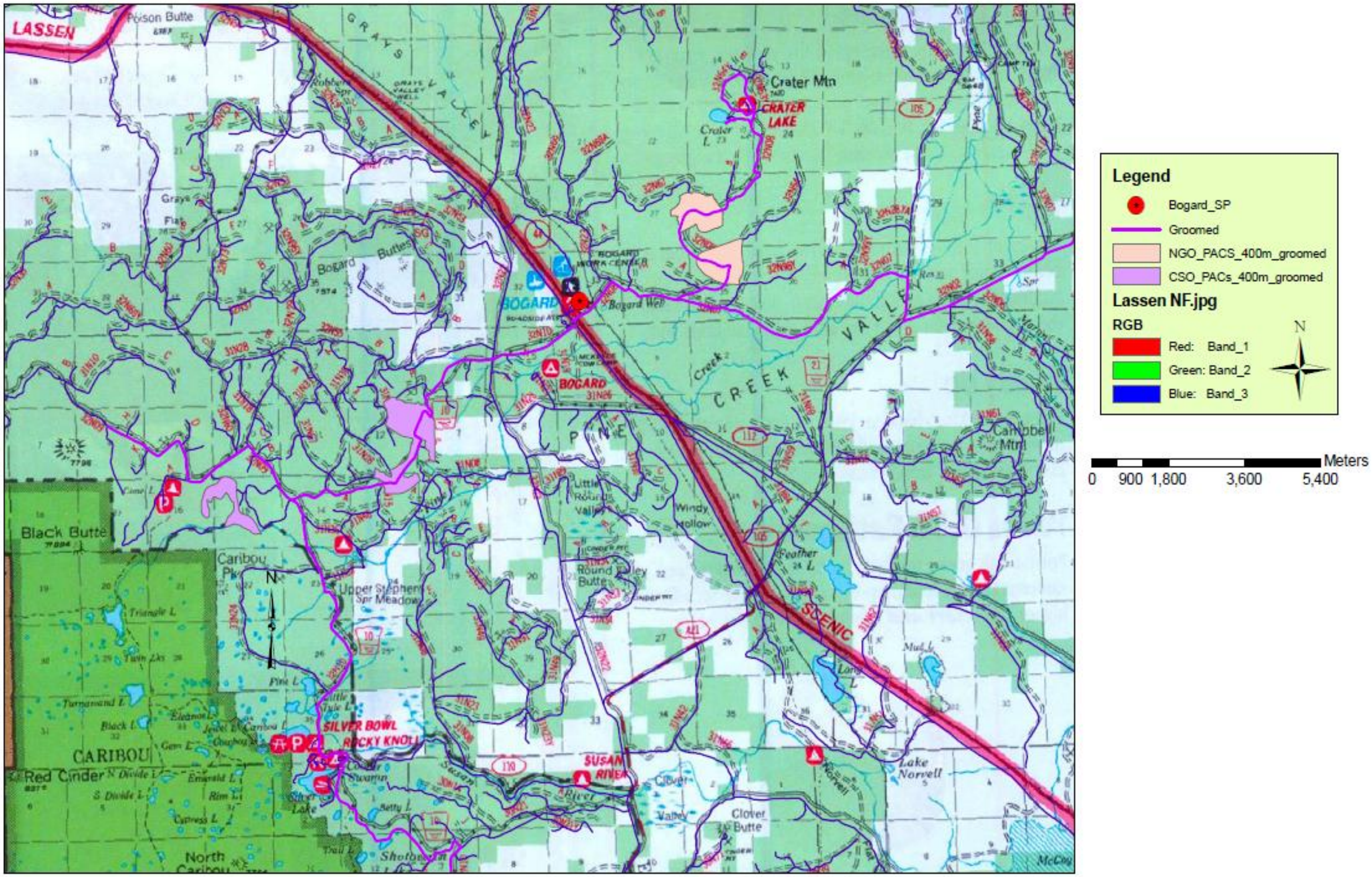


Figure 5. Eagle Lake RD- CSO and NGO PACs within 400m of Swain Mountain Snow Park OSV routes, Lassen NF.

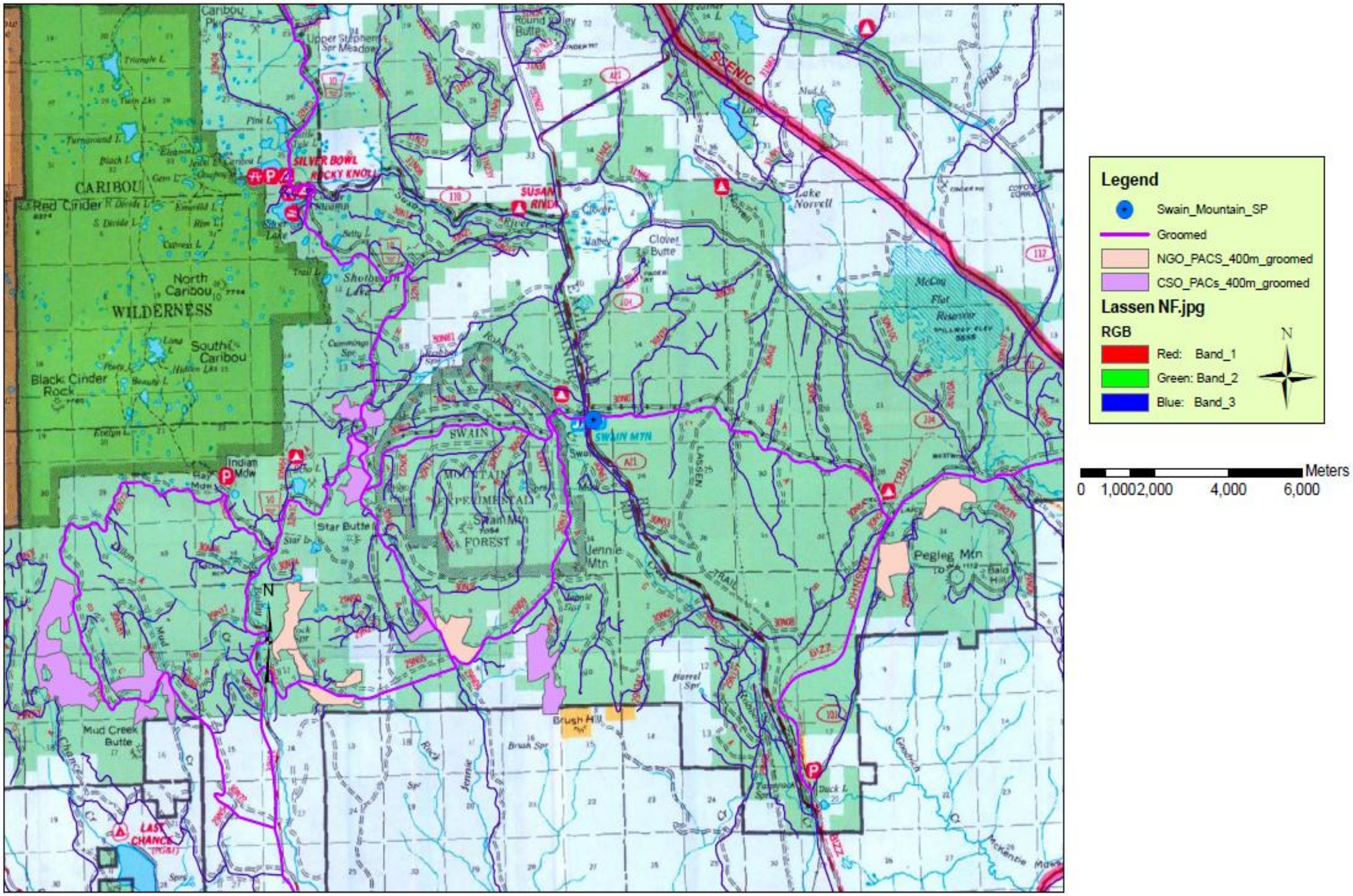
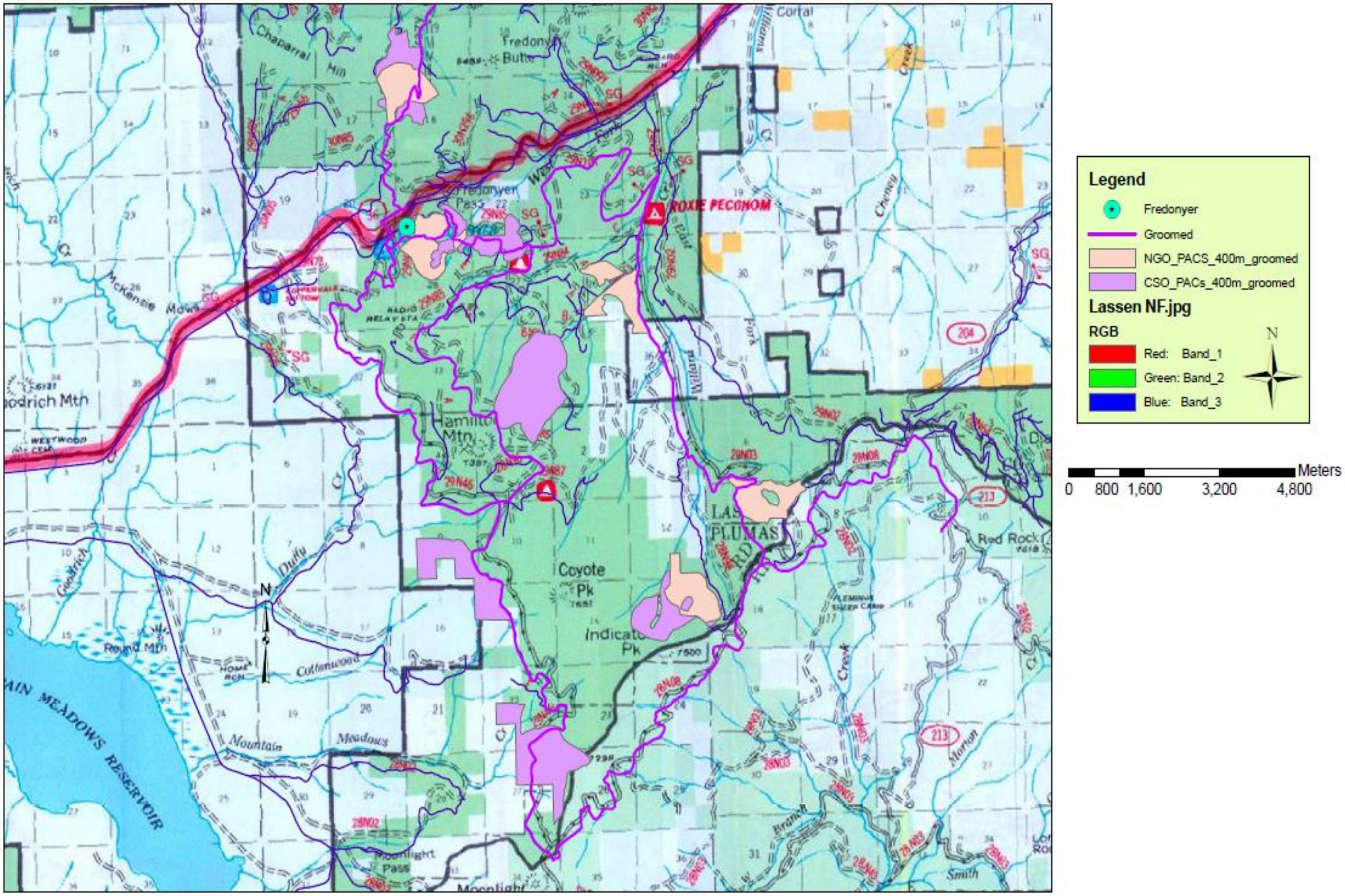


Figure 6. Eagle Lake RD- CSO and NGO PACs within 400m of Fredonyer Snow Park OSV routes, Lassen NF.



Comment Letter #2: Center for Biological Diversity

CENTER *for* BIOLOGICAL DIVERSITY

VIA ELECTRONIC MAIL AND U.S. MAIL

November 21, 2010

California Department of Parks & Recreation
Off-Highway Motor Vehicle Recreation Division
Ms. Connie Latham – Associate Park and Recreation Specialist
1725 23rd Street, Suite 200
Sacramento, CA 95816
osvprogrameir@parks.ca.gov

Re: Comments on Over Snow Vehicle Program Draft Environmental Impact Report Program Years 2010 – 2020 (State Clearinghouse # 2009042113)

Dear Ms. Latham:

The Center for Biological Diversity ("Center") submits these comments on the California Department of Parks & Recreation, Off-Highway Motor Vehicle Recreation Division's Over Snow Vehicle Program Draft Environmental Impact Report Program Years 2010 – 2020 (State Clearinghouse # 2009042113) ("DEIR") regarding the Division's proposed 10-year funding commitment of the Over Snow Vehicle (OSV) Program for the operation, maintenance, and grooming of winter recreation trails and trailheads in mountainous regions throughout California ("proposed project" or "program").

The Center is a non-profit environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center has over 255,000 members and online activists throughout the United States including many members who reside in California, visit the areas that are impacted by the program, and have interests in the preservation of the species that are impacted by the program. The Center incorporates by reference herein the comments on the DEIR submitted by the Snowlands Network, Winter Wildlands Alliance, The Wilderness Society and the Center for Sierra Nevada Conservation, and provides the following additional comments.

#2-1

Identification and Analysis of Impacts to Biological Resources, Including Imperiled Species, is Inadequate.

Baseline: The DEIR does provide some detailed information regarding significant

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#2-1

impacts to listed, rare, and imperiled species that are affected by the proposed project.[1] However, the DEIR largely dismisses these impacts and fails to address ways to avoid, minimize, and mitigate these significant impacts to imperiled speciesby attempting to shield them from review as part of the "baseline" conditions. The DEIR attempts to describe activities which occur newly each year as "ongoing" activities—this is inaccurate. In this case the existing environment or baseline that should have been used is the condition on the ground each year before any snow grooming and clearing activities commence.

CEQA defines the "baseline" as "the physical environmental conditions in the vicinity of the project, as they exist at the time the notice of preparation is published." (CEQA Guidelines, § 15125, subd. (a).) The notice of preparation was issued for this project on April 24, 2009, well before any 2009 snow grooming or clearing activities would have commenced and far before any activities undertaken under the proposed ten year project would begin. Under CEQA, the DEIR should compare existing physical conditions with the physical conditions that are predicted to exist at a later -- after the proposed project is approved and the project impacts occur. In evaluating project impacts, courts have repeatedly held that existing, actual existing environmental conditions control, not hypothetical ones that would otherwise serve to minimize the impacts of the proposed project and allow the agency to avoid analysis and mitigation. *See, e.g., Woodward Park Homeowners Ass'n, Inc. v. City of Fresno*, 150 Cal. App. 4th 683, 691 (2007) ("hypothetical office park was a legally incorrect baseline [against which to measure significance] which resulted in a misleading report of the project's impacts."); *Env't Planning & Information Council v. County of El Dorado*, 131 Cal. App.3d 350 (1982) (EIR for area plan invalid because impacts were compared to existing general plan rather than to existing environment).

Because the baseline determination "is the first rather than the last step in the environmental review process," (Save Our Peninsula Committee, at p. 125), an inaccurate baseline undermines all of the analysis of impacts in the DEIR. Here, the baseline chosen by the Division is legally insufficient because it fails to compare what will happen if the proposed funding is approved with what will happen if the proposed activities do not occur each year—that is if these sites are left alone going forward. *See Woodward Park Homeowner's Assn., Inc. v. City of Fresno* (2007) 150 Cal.App.4th 683, 707 (the EIR must do "what common sense says it should do and what the EIR's most important audience, the public, will naturally assume it does: compare what will happen if the project is built *with what will happen if the site is left alone*." [emphasis added]).

In sum, the DEIR's analysis is fatally flawed from the outset because it used an inaccurate baseline. For biological resources this error is of particular concern because it has lead the Division to conclude that even thought there are admittedly significant impacts to many rare, imperiled and special status species from the proposed project, the Division need not look at

[1] The Division notes that the Department of Fish and Game is a trustee agency but does not discuss whether the Department has provided any input on the proposed project to date. The Division also appears to have failed to acknowledge in the DEIR all of the responsible agencies including, Department of Fish and Game, regional water boards, and the State Water Resources Control Board.

ways to avoid, minimize and mitigate these impacts. As a result of the inaccurate baseline, the alternatives considered are far too narrow and the alternatives analysis is inaccurate as well. This is a clear violation of both the letter and spirit of CEQA. The DEIR must be supplemented or revised and re-circulated to take into account a proper baseline from which to analyze the impacts of the proposed project.

#2-2

Alternatives: Under CEQA, a lead agency may not approve a project if there are feasible alternatives that would avoid or lessen its significant environmental effects. (Public Resources Code §§ 21002, 21002.1(b).) To this end, an EIR is required to consider a range of potentially feasible alternatives to a project, or to the location of a proect, that would feasibly attain most of the project's basic objectives while avoiding or substantially lessening any of the project's significant environmental impacts. (*Save Round Valley Alliance v. County of Inyo* (2007) 157 Cal.App.4th 1437, 1456.)

As the Supreme Court put it:

> The core of an EIR is the mitigation and alternatives sections. The Legislature has declared it the policy of the State to "consider alternatives to proposed actions affecting the environment." (Pub. Resources Code, § 21001(g); *Laurel Heights*, supra, 47 Cal.3d at p. 400.) Section 21002.1, subdivision (a) of the Public Resources Code provides: "The purpose of an environmental impact report is to identify the significant effects of a project on the environment, *to identify alternatives to the project*, and to indicate the manner in which those significant effects can be mitigated or avoided." (Italics added. See also Pub. Resources Code, § 21061 ["The purpose of an environmental impact report is . . . to list ways in which the significant effects of such a project might be minimized; *and to indicate alternatives to such a project.*"].)

(*Citizens of Goleta Valley v. Board of Supervisors* (1990) 52 Cal.3d 553, 564-65 [italics in original].)

#2-3

Because the proposed project affects a wide range of habitat types within the montane regions from 4,000 to 10,000 feet in elevation it has the potential to significantly affect many imperiled, rare and special status species, including several fully protected species. Because the proposed project facilitates high levels of motorized OSV use in habitat for many imperiled wildlife species and also impacts movement corridors the proposed project has significant impacts to species that should be avoided, minimized and mitigated. The wildlife species that will be adversely impacted by the proposed project include, but are not limited to, the following: California spotted owl, Northern spotted owl, great grey owl, northern goshawk, bald eagles, golden eagles, pacific fisher, Sierra Nevada red fox, mountain lion, Yosemite toad, and Sierra Nevada mountain yellow-legged frog. Rare plants and riparian and wetland habitats can also be significantly impacted particularly due to compaction and riding in areas where snow is thin or riding over or across wetland and riparian areas which can significantly impact soils and soil structure.

Wildlife are directly affected by OSV use in many ways as noted in the DEIR:

#2-3

> The OSV Program could have both direct and indirect impacts on wildlife. These impacts are associated with vehicle collision, home range use, breeding, physiological stress, opening corridors for predators that would not ordinarily be available, and snow compaction, ... It is possible that OSV use would have a greater impact on wildlife during severe winters when wildlife is already stressed by environmental conditions. (DEIR at 5- 32 to 33.)

#2-4

The DEIR notes but does not "count" many significant impacts which are considered as part of the "baseline" or "ongoing" or a result of "continued funding", although, in fact, these impacts occur anew each year and are significant. The DIER acknowledges that any increases would also be significant and even these that so-called "ongoing" impacts my adversely affect already impaired species. For example, at the DEIR states:

> Home Range Use. Noise and extended human presence from OSV activities could reduce the size of the winter home range for several wildlife species. The home range provides food, shelter, and breeding opportunity, and if it is reduced, could compromise species survival, particularly during stressful survival conditions in the winter. Trail grooming activities occur at night, are infrequent, and move slowly enough that grooming is not expected to have a substantial adverse effect on wildlife home range. Many of the species that may be active or present during the OSV Program season are nocturnal and may not be affected by daytime snowmobile activities at all; however, 29 percent of snowmobilers report some nighttime riding[2] (Project Description, Table 2-9). This can include daytime riders who do not return to the trailhead before early nightfall and those that ride in late night hours. For diurnal species, OSV use of the trails may result in animals avoiding areas used by snowmobilers. For nocturnal and crepuscular species trail grooming and OSV use may also result in animals avoiding areas frequented by snowmobilers and groomers. *The continued funding* of the Program would not change the extent of existing effects; however, with the anticipated increase in riders accessing the backcountry, extended human disturbance may reduce the home range for special-status wildlife species. The impact by the OSV Program is not considered to have a substantial adverse effect on common species' populations or home range use either directly or through habitat modifications. *However, an adverse impact may be felt by special-status species already pressured by existing forest uses and by an increase in riders.* The national forests operating under the OSV Program operate under numerous Land Resource Management Plan policies (Appendix D) that address this issue and mitigate any substantial adverse impact to less than significant.
>
> Breeding Disruption. If the winter season overlaps with the beginning of breeding season as may be the case for species such as the yellow-bellied marmot and other birds and mammals, the presence of OSVs in the forests could disrupt courtship

[2] Notably, the DEIR also states that: "Trail grooming generally occurs at night between dusk and sunrise." (DEIR at 5-33).

#2-4

> and nesting or denning activities due to noise and/or visual disturbance that result in behavioral changes in the animals. *This ongoing impact*, along with the anticipated increase in riders over the next 10 years, may have a minor to moderate effect on common species as it would affect individuals, but it would not affect the viability of common wildlife species' populations. For special-status species, *breeding disruption could be a significant adverse impact to a species with an already low population.* With the implementation of the Management Actions already in use (Table 5-5) by the national forests and Mitigation Measures BIO-1 and 2 identified below in Section 5.4, the project impacts during early courtship and nesting/denning periods would remain at existing levels. *No new impacts would occur as a result of the continuation of the OSV Program* and therefore, the Project's effect on special-status birds is less than significant. (DEIR at 5-33 to 34 [emphasis added].)

#2-5

As a result the DEIR is both equivocating and inaccurate— special listed, rare, and other special status species are already imperiled and declining under the current Forest Service management including the activities that have been funded by the Division in the past. Moreover, there is no showing that the land management plans have in fact mitigated such impacts in the past or will adequately do so in the future. To the contrary, there is substantial evidence that the proposed project will support significant impacts occurring again in the future that are similar to in the activities in the past that contributed to the decline of these special status species and that it will also support increasing impacts in the future if it is approved. As a result, already imperiled species will be impacted once again and increasingly under this proposed project undermining their survival and chances for recovery. The DEIR fails to adequately disclose these facts or to provide adequate alternatives to avoid them or measures to minimize and mitigate these impacts in violation of CEQA.

#2-6

Moreover impacts to plants, wetlands and other resources due to compaction, degradation, or in areas where snow is thin and soils are directly affected are also significant and must be avoided where feasible, and minimized and mitigated. It is not sufficient for the Division to rely on the Forest Service plans to protect these species many of which have continued to decline under current Forest Service management. Promises of future "adaptive management" actions based on future studies are also insufficient to meet CEQA's requirements for avoidance, minimization and mitigation.

#2-7

Alternatives are available that would avoid and significantly reduce impacts to species if the proposed project were denied or one of the alternatives selected. As the DEIR admits (even based on the under-estimated impacts of the project) the alternative of Funding of Restricted Riding Areas Only would be the environmentally superior alternative because it significantly avoid many impacts of the proposed project. (DEIR at 9-11, 9-7 to 9-10)

#2-8

In contrast, the DEIR also rejects a similar alternative Closure of Off-Trail Riding Areas as "infeasible" based on an erroneous re-framing of the issue as whether the Division itself could close areas to off-trail riding. (DEIR at 9-2.) Even if the Division cannot <u>alone</u> close areas to off-trail OSV use, it could significantly influence the level of such activities by not funding any grooming and clearing activities in areas where off-trail riding is allowed. As the DEIR

#2-8 elsewhere admits, this would reduce the use of those areas significantly leading to improved conditions for wildlife and other biological resources. In fact, even though the Division is not the land manager for the trails at issue, the Division's control of significant funding for the trail grooming and clearing activities provides it with the ability to select from wide a range of alternatives that would likely result in significant avoidance and reduction of impacts to biological resources. Similarly, the rejection of a prohibition on two-stroke engines is formulated such that it is not feasible but a feasible alternative is available—the Division could decline to fund activities in any areas that allow two-stroke OSVs. To propose alternatives simply to reject them is little more than a slight of hand, setting up "straw-man" alternatives only to reject them fails to meet CEQA's requirements that the agency consider a range of alternatives.

#2-9 *Cumulative Impacts:* In addition to relying on a flawed baseline for biological resources and failing to adequately address alternatives, the DEIR also fails to adequately consider the impacts of past OSV activities in the analysis of cumulative impacts to biological resources. For example, the DEIR fails to consider the impacts of past snow grooming and clearing activities and OSV use resulting from the Division's funding activities which may have already contributed to the imperiled and declining status of many species in these areas. (DEIR at 5-50 to 51.)

The cumulative impacts that must be considered include, "the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time." CEQA Guidelines Section 15355(b). In addition to considering other activities in these areas that may affect the biological resources, and specifically wildlife, the DEIR should have taken into account the cumulative impact of the proposed project in conjunction with the past grooming clearing and OSV activities that have caused impacts to the biological resources in these areas as well.

Cumulative impacts analysis is a critical part of any CEQA analysis.

> [t]he cumulative impact analysis must be substantively meaningful. "'A cumulative impact analysis which understates information concerning the severity and significance of cumulative impacts impedes meaningful public discussion and skews the decisionmaker's perspective concerning the environmental consequences of the project, the necessity for mitigation measures, and the appropriateness of project approval. [Citation.]' [Citation.] [¶] While technical perfection in a cumulative impact analysis is not required, courts have looked for 'adequacy, completeness, and a good faith effort at full disclosure.' (Cal. Code Regs., tit. 14, § 15151.) "A good faith effort to comply with a statute resulting in the production of information is not the same, however, as an absolute failure to comply resulting in the omission of relevant information." [Citation.]" (*Mountain Lion Coalition v. Fish & Game Comm.* (1989) 214 Cal. App. 3d 1043, 1051-52.)

(*Joy Road Area Forest and Watershed Assoc. v. Cal. Dept. of Forestry* (2006) 142 Cal. App. 4th 656, 676.)

#2-9 Where, as here, the impacts of a project are "cumulatively considerable" the agency must also examine alternatives that would avoid those impacts and mitigation measures for those impacts. (CEQA Guidelines §15130(b)(3).) The DEIR must be supplemented or revised and re-circulated to take into account all of the cumulative impacts of the proposed project.

#2-10 For each of these reasons, and others, the identification and analysis of impacts to biological resources in the DEIR is inadequate and must be revised or supplemented and the revised information and analysis must be re-circulated for public review and comment.

The Identification and Analysis of Impacts to Air Quality is Inadequate and Incomplete Regarding Greenhouse Gas Emissions.

#2-11 The DEIR provides information on the greenhouse gas emissions from the direct activities and the use of the trails that will occur under the proposed project as well as the increase in emissions likely over the 10-year life of the proposed project. However, the analysis of the significance of these emissions is inadequate. For the so-called baseline emissions, the DEIR makes an unfounded assumption that "Although these current conditions are contributing toward the statewide exceedance of the GHG emissions levels in excess of the 1990 rollback goal specified for the state, the impact is not considered significant as it is not a net increase above the current baseline and is not a net increase in GHG." #2-12 The DEIR states that for baseline the levels of direct GHG emissions are not significant and although the DIER admits that the indirect GHG emissions (including both OSV use and travel to and from the area) from the baseline levels which would continue under the proposed project are cumulatively considerable (DEIR at 4-32 to 33).

#2-13 First, the Division is wrong that these emissions are properly analyzed as "baseline" because they will only continue to occur at the past levels if the proposed project goes forward and provides yearly funding. The correct baseline is the conditions in these areas each year before any snow grooming activities or snow clearing begins, and each year these emissions are "new" emissions. Second, even if these emissions were properly considered "ongoing", these so-called baseline emissions are significant and should be avoided, minimized, and mitigated. The failure to immediately and significantly <u>reduce emissions from existing levels</u> will result in devastating consequences for the economy, public health, natural resources, and the environment. Based on the scientific and factual data, these emissions meet thresholds developed by many agencies (as the Division recognizes in its discussion of the growth in emissions) and the Division's failure to consider ways to reduce these emissions is unsupportable in the face of the profound threats posed by global warming.

#2-14 Substantial guidance on reaching a determination of significance for greenhouse gas impacts is available. For example, in January 2008, the California Air Pollution Control Officer's Association (CAPCOA), released a white paper entitled CEQA and Climate Change: Evaluating and Addressing Greenhouse Gas Emissions from Projects Subject to CEQA (available at www.capcoa.org). Among other topics, the paper discusses different approaches for making a determination whether a project's greenhouse gas impacts would be significant of less-

#2-14 than-significant. Notably, CAPCOA concluded that only a threshold of zero or 900 tons was highly compliant with California's emission reduction objectives and highly effective at reducing emissions. Accordingly, a threshold of zero has been used to analyze project GHG impacts and should be applied here. *See, e.g., Communities for a Better Env't v. City of Richmond*, 184 Cal.App.4th 70 (2010).

#2-15 For the GHG emissions growth the proposed project will support the DEIR states that it does reach the significance thresholds adopted by several agencies (DEIR at 4-35) but then dismisses these thresholds because the proposed project is "statewide". However, the use of the per capita "efficiency-based threshold" makes little sense in this context. The DEIR states: "The BAAQMD has also developed an efficiency-based threshold of 4.6 MTCO2e per service population per year that is meant to allow efficient projects with higher mass emissions to meet the overall GHG reduction goals of AB32." (DEIR at 4-35.) The proposed project is not an "efficient" project in the context in which those thresholds were developed. The use of the per service population per year standard as an alternative to a hard cap of 1,100 MTCO2e was intended to accommodate larger projects that would potentially *increase* efficiencies and therefore a larger "service population" would be benefited.[3] Thus the use of the efficiency-based threshold can not properly be applied to this proposed project in conformance with the BAAQMD standards. Indeed, that the BAAQMD standard is mis-applied is quite clear in this case where the so-called "analysis" proffered by the Division amounts to little more than adding up the emissions from the equipment use and OSV users themselves and then dividing them again—this shows that there is no "service population" across which any efficiency is being spread. As a result, the DEIR entirely fails to address the cumulatively considerable GHG emissions that result from this proposed project.

#2-16 In order to comply with CEQA and the State's GHG goals, the Division must look at ways to avoid, minimize and mitigate the GHG impacts of this proposed project in a supplemental DEIR. The use of diesel fuel for the trail maintenance equipment is of particular concern as it not only releases GHGs but also increases other air pollutants and deposits particulate matter directly on snow surfaces. Recent studies have shown that this kind of soot contributes to early snow melt and can accelerate the impacts of global warming in conjunction with GHGs. Avoidance measures could include, for example: requiring a shift from diesel to other cleaner fuels on an accelerated schedule (rather than passively assuming some beneficial changes might occur in the future); adopting the environmentally superior alternative of limiting funding to those areas which require OSV to stay on trails ("Funding Restricted Riding Areas Only" alternative) which would significantly reduce use and GHGs; and/or limiting funding support to those areas which allow only OSV that emit lower emissions such as newer four-stroke engines (i.e., prohibiting two-stroke engines).

#2-17 Thank you for your consideration of these comments. We look forward to reviewing a Supplemental DEIR for this project that accurately portrays the impacts of the proposed project including impacts to biological resources and GHG emissions and provides for alternatives that

[3] Moreover, the proposed rules for the BAAQMD specifically noted that if the project's emission on a mass level will have a cumulative considerable impact on the region's GHG emission, then the efficiency-based threshold would be overcome. Such is the case here.

avoid those impacts, and minimization and mitigation of any remaining impacts. Please include me on the notice list for all documents and actions related to this project going forward. Do not hesitate to contact me if you have any questions regarding these comments.

Sincerely,

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Comment Letter #3: Recreation Outdoors Coalition

Recreation Outdoors Coalition

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State Of California, Department of Parks and Recreation

Off-Highway Motor Vehicle Recreation Division

P.O.B. 942896

Sacramento, CA 95816

Re: Over Snow Vehicle Program Draft Environmental Impact Report

#3-1

Thank you for this opportunity to comment on your DEIR for the ten-year funding commitment of the Over Snow Vehicle (OSV) Program for the maintenance and grooming of winter recreation trails and trailheads throughout California. Although the primary purpose of this program is to benefit motorized vehicles by plowing roads, grooming trails and maintaining facilities it also benefits non-motorized users as well. When these funds can be of benefit to more than just the intended purpose it is a wise expenditure of funds.

#3-2

The preparation of a ten year funding program makes sense. Agencies receiving these funds will know for years in advance that the funds will be there and are stationary. Not having to go through the process every year should also save money by eliminating the yearly planning.

#3-3

With the projected increase in population and inadvertently in this type of use it is important to look at how to meet the needs in the future. By keeping up with the growth and increased needs the public is better served than waiting until the use increases past bearing capacity and trying to deal with the problems related to overuse and under service. Right now, when one looks at the date of establishment of this program and the lack of continual expansion to meet the increased needs I believe this has been a very well managed program. However, how long can it sustain the increased growth without an increase of opportunities? The snow and the open areas are available so expansion of the winter program does not put an additional strain on the resources. Increasing managed, well planned trailheads keeps riders in appropriate locations and not in areas such as wilderness areas and on private lands where use is inappropriate.

#3-4

In looking at the number of groomed miles compared to the number of OSV's today average use is .011 miles of groomed trail per vehicle. If projected growth materializes and there is no increase in groomed miles by 2020 the number of miles of groomed trails per OSV will be .007 which has them on top of each other on a busy day. Safety could be compromised and chances of increased conflict could occur.

When reviewing this document I find the following conclusions:

#3-5 To provide a quality OSV Program it is obvious why this plan rejects a number of alternatives listed in this document.

#3-6 Since the inception of groomed trails the number of OSV's using these trails has increased much faster than additional trails. With the projected further growth it is imperative that the winter program be expanded. A number of potential sites have been identified that will help to accommodate this growing need. First things to look at are safety and management. Areas that would create a challenge to manage should rank lower on any scale of development.

#3-7 Although no new trailheads or expansion are proposed at this time this possibility should not be ignored. Because of the time involved in the planning and implementation of any new opportunities we should be ever diligent in seeking and planning new activities in the event the financial shape of the state changes and the opportunity to entertain an expansion should occur. Increased parking and grooming at acceptable locations could help with expected congestion with increased volume of OSV's.

#3-8 This document is very comprehensive, well written and covers all aspects of OSV activity. However, there are several areas where I would like to either see more information or the information is not correct.

#3-9 It would be helpful to see a graph on the increase in snowmobiles by the year. The average for the 10-year period reflects 4% growth per year spread over each year the greatest growth has been in the past five years which would reflect a much greater growth rate for the next ten years should the economy turn around.

#3-10 On page 2-15 in **Table 2-6. OSV Program, Plowed Access Roads And Trailheads** the Contract Agency/Service Provider listed for Lassen/Morgan Summit is listed as Lassen NF/Caltrans. I believe the main service provider in this instance is the Lassen Volcanic National Park.

#3-11 While the Lassen Volcanic National Park is listed in **Table 3-2. As a Special Interest Area in Project Area Vicinity** this park is about 5 miles from Morgan Summit and it is virtually impossible to ride a snowmobile from the designated OSV area to any portion of the park. The riding area is south of Highway 36 and a designated cross country ski area is on the north side of the highway. These two obstacles, along with the topography, make it impossible to trespass from the OSV area..

#3-12 On page 3-12 under **3.3.2.2 OSV Intrusion into Closed Areas, further, Wilderness Areas and the Lassen National Forest** there are two errors in information. The statement, "Trespass into Lassen Volcanic National Park likely originates from Ashpan or Morgan Summit trailhead". As explained prior it is virtually IMPOSSIBLE to access LVNP from Morgan Summit Trailhead due to highway, cc ski area and topography of the park on that side. Ashpan is also on the north side of Hwy 44 and does not lend itself to any trespass on that side. Any trespass into the park on the south side likely comes from the area between Childs Meadows, east of Mineral across Mill Creek, and the Chester area. On the north side of the park trespass most generally occurs from USFS road 29N17 and Bogard area, where signage is poor at best.

#3-13 This false information is again reflected on page 3-14 in **Table 3-3. OSV Intrusion Areas, 2009** the origin of perpetrators are again listed as Ashpan and Morgan. It is very difficult to access LVNP from Ashpan as there has to be a high snowfall to access the park from that side and it is virtually impossible to do so from Morgan.

#3-14 Caribou Wilderness is accessible from Swain, Bogard and Chester trailheads.

#3-15 On page 8-10, **Table 8-3. OSV Program Parking Demand, Baseline 2010** the table shows Morgan Summit at potential parking number of 16, with no overflow frequency. There have been a number of days where this lot is completely full, most of the vehicles being for snowplay participants. Snowmobilers have the choice of driving back to the community of Mineral or on into Chester to find suitable off road parking. There are pictures that verify this situation. Discussion has gone on with the Almanor District Office about the potential of enlarging this parking area or creating an additional parking area for snowplay in a different location. However, these discussions have gone nowhere.

#3-16 It is nice to see that this Division has one eye to the future in preparing for growth in OSV use. The areas selected for future expansion are very suitable and well located. The Lake Davis area is well suited for expansion. This area was previously on the Plumas National Forest winter recreation map as a trailhead for OSV and needs to be put back on the map. Until the funds are available from the winter program to provide a groomer and fuel the community is working on a plan to provide these services temporarily to help provide revenues to the community. While attending a poker run in the area last winter a large group from the Reno area was heard to say that if they had grooming at the Lake they would spend much more time there as opposed to going to Tahoe which is impacted with riders. They do come when there is a poker run because they know the trails will be groomed at that time by the local power company for the event.

Information contained in this DEIS is well articulated and very thorough in explaining all aspects of current and fuiture use and potential growth. Division should be commended for a job well done.

Respectfully submitted.

Sylvia Milligan

Sylvia Milligan, Chair

Recreation Outdoors Coalition

Comment Letter #4: Snowlands Network

SNOW LANDS Network

Promoting opportunities for quality, human-powered winter recreation and protecting winter wildlands

California Department of Parks & Recreation
Off-Highway Motor Vehicle Recreation Division
1725 23rd Street, Suite 200
Sacramento, CA 95816
Attention: Ms. Connie Latham – Associate Park and Recreation Specialist
VIA EMAIL: osvprogrameir@parks.ca.gov

November 19, 2010

RE: Comments on Over Snow Vehicle Program
Draft Environmental Impact Report
Program Years 2010 – 2020

Dear Sirs:

Snowlands Network, Winter Wildlands Alliance, The Wilderness Society and the Center for Sierra Nevada Conservation ("Petitioners") hereby comment on the proposed ten-year funding commitment to the Over Snow Vehicle Program by the California Department of Parks and Recreation, Off-Highway Motor Vehicle Recreation Division (the "Agency"), and on the associated Draft Environmental Impact Report dated October 20, 2010.

Snowlands Network represents the interests of skiers, snowshoers and other winter recreationists who desire to recreate in areas free from motorized use in California and Nevada. Snowlands has 560 members.

Winter Wildlands Alliance is a national nonprofit organization promoting and preserving winter wildlands and a quality human-powered snowsports experience on public lands nationwide. It has 1,300 members and 40 affiliated organizations who together have an additional 30,000 members.

The Wilderness Society is the leading American conservation organization working to protect our nation's public lands, the 635 million acres collectively owned by the American people and managed by our government. Today, with more than 500,000 active members and supporters, TWS continues its vital mission to protect wilderness and inspire Americans to care for our wild places.

The Center for Sierra Nevada Conservation advocates sound management of public lands and wise government land use policies.

Several of the Petitioners have previously commented to the Agency on the issues presented by this project.[1]

#4-1 The Agency sorely underestimates the impact of its grooming program. The Agency's grooming program in fact is having a huge impact on shaping winter recreation opportunities in California. The program has substantial impacts on the natural environment, including wildlife, water quality, air quality and vegetation – as well as on local economies -- that have not been adequately addressed. The program needs to be modified including through additional mitigation measures.

#4-2 All or almost all the Agency's grooming programs are on lands administered by the United States Department of Agriculture, Forest Service. The Agency relies on mistaken assumptions regarding Forest Service attention to the above issues in order to conclude that its program has an insignificant impact. In fact, the Forest Service is not adequately addressing the user conflicts and reduced recreational opportunities for clean and quiet winter sports caused by this grooming program. The Forest Service is not providing mitigation efforts (through law enforcement, etc) at an effective level.

#4-3 Among other mitigation steps, Petitioners respectfully urge that a portion of the OSV program funds be used to create and maintain trailheads plowed and reserved for human-powered recreation. This will have substantial benefits to the local economies. The sports of backcountry skiing and snowshoeing are two of the fastest growing sports and can substantially contribute to the economies of local communities in and near California's national forests.

#4-4 A growth in human-powered recreation will, in fact, substantially contribute to these economies. An economic impact study conducted by the Gallatin National Forest in 2005 found that non-motorized users generated nearly twice as much spending as motorized users. The study found that non-motorized recreation generated $7.3 million in economic activity and supported 330 jobs while motorized recreation, particularly snowmobiling, created $3.9 million in spending and 185 jobs. These statistics and examples illustrate the economic importance of protecting opportunities for quality non-motorized winter recreation.

#4-5 The importance to the people of California in having opportunities for quiet, healthful and clean winter recreation is well-known to the Agency. We ask that the Agency recognize the impact of its grooming program on quiet, human-powered recreation and make adjustments to its program to appropriately balance motorized and non-motorized recreation.

***

I. General Discussion
II. Specific Faulty Statements or Assumptions in the DEIR
III. Necessary Changes and Mitigation

[1] Letter dated December 19, 2008, and other communications.

I. General Discussion

#4-6

It is a basic fact that some forms of recreation are low impact, and some are high impact. Low impact recreation does not significantly impact the environment or detract from the recreational experience of other users, while high impact recreation does.

- An extremely low impact recreation is skiing or snowshoeing across hardened snow.
- An extremely high impact recreation is driving a fossil fuel-powered over-snow-vehicle across a wild landscape.

The huge disparity between the above recreational uses sets the background for our comments.

Snowmobiles are a high impact recreational use that impact wildlife, air quality, water quality and vegetation to a greater degree than the Agency has acknowledged. In the last fifteen years, technology has vastly expanded the capabilities of snowmobiles. They can now travel into remote backcountry areas previously not threatened by their impact. These machines are loud, fast, and require skilled operators for safety. As Winter Wildlands has stated,

> "Until the 1990's, there was little overlap between motorized and non-motorized winter forest users. Before that time, motorized use was generally restricted to packed trails and roads as early snowmobiles would easily become bogged down in deep snow. Skiers and snowshoers wishing to avoid motorized impacts could go off trail to areas unreachable by snowmobile. In the 1990's, however, the development of the "powder sled" vastly increased the reach of snowmobiles allowing the newer, more powerful machines to dominate terrain previously accessible only by backcountry skis or snowshoes and putting the two user groups on the current collision course."[2]

#4-7

The Agency has turned a blind eye to this issue of user conflicts, by hiding behind the notion of multiple use. Multiple use does not mean multiple use on every acre of ground, nor on every trail. Some uses are not compatible with other uses, and must be constrained or they will monopolize recreation opportunities. <u>This is happening in California.</u> The Agency's actions through this program substantially favor the use of forest lands for motorized recreation over human-powered recreation. This creates de facto single-use forest lands. *In contrast to current practice, the concept of "multiple use" calls for balancing motorized and human-powered opportunities. This necessarily means closing some areas to snowmobiles in order to ensure the continued availability of places for quiet, non-motorized recreation experiences.*

#4-8

A fundamental difference between winter recreation and summer recreation on national forest lands is access. In winter, trailheads start only from plowed roads, and only from plowed roads where there are plowed parking areas. Winter parking access is less than 1% of summer parking access. Thus, the Agency's program, in making trailheads available for OSV use, is a critical factor in shaping winter recreation in California.

[2] Winter Wildlands Alliance, Winter Recreation on Western National Forest Lands, 2006, at p. 1.

#4-8 The trailheads plowed under this program, and under the Sno-Park program (which also benefits motorized users) provide, in many areas, the only reliable access to winter recreation on forest lands. But, with a few exceptions, they are monopolized by snowmobiles. Accordingly, the program creates a huge and unfair balance, with Forest Service lands – which are intended to be multiple use – devoted to serving a small percentage of users. Agency data confirms this gross imbalance, showing more than TEN times as many trails groomed for snowmobile recreation as for nonmotorized recreation in California National Forests (DEIR Table 8-2). Agency data shows very few plowed access points where clean and quiet recreation opportunities are protected.

#4-9 It is a fact, not a conjecture, that skiers and snowshoers do *not* want to recreate in the vicinity of snowmobiles. Many of these winter recreationists specifically seek quiet lands free from the whine and noxious emissions of motorized transport. For many people, outdoor recreation means the absence of noise and noxious exhaust.

Due to their noise and air pollution and the relative barrenness of the winter landscapes, snowmobiles perhaps have a unique ability to disturb a great many people over a wide area. Reported conflicts are minimized because skiers and snowshoers avoid these areas. CDPR's 2009 Winter Trailhead Survey results confirm this fact, with skiers and snowshoers constituting less than 16% the number of snowmobilers at OSV program locations, despite there being far more skiers and snowshoers in California than snowmobilers. Many if not most of that 16% are at the OSV program area only because of the lack of comparable areas reserved for quiet recreation. They quietly suffer a poor recreation experience because it is better than none at all. Because areas protected for quiet recreation are very limited, the result is an artificial promotion of the sport of snowmobiling by the State of California and the Forest Service, and an artificial repression of the quiet and environmentally favorable, low-impact sports of skiing and snowshoeing.

#4-10 The Agency proposes to exacerbate this huge imbalance by the creation of additional OSV trailheads to its program. This will further encourage the growth of snowmobiling to the detriment of human-powered winter recreation. More trailheads and more areas will become monopolized by OSV vehicles and human-powered recreationists will lose the remaining quiet recreation opportunities that currently exist.

#4-11 Petitioners submit that these human-powered sports serve stated government policies to a far greater extent than gas-powered high-impact sports. Human-powered sports can provide opportunities for the greatest number of individuals, do not stimulate our dependency on oil, do not in themselves contribute to global warming, provide a larger benefit to local economies and do not impact the State's air quality, water quality and wildlife.

#4-12 Petitioners also submit that these sports would achieve any even larger popularity and much higher use numbers *were the State of California and the Forest Service to provide human-powered recreationists a fair share of recreational opportunities.* Instead, the OSV grooming program, by placing large numbers of OSV vehicles at the primary locations for winter recreation, is monopolizing federal lands for a single purpose and retarding the growth of human-powered recreation. Snowmobiling as a sport is encouraged, while cross-country skiing, snowshoeing, and other low-impact forms of winter recreation have their recreation opportunities taken away. Trailheads that might otherwise be open to quiet winter recreation are being monopolized by snowmobiles.

#4-13

NVUM data demonstrates that skiers and snowshoers outnumber snowmobilers. In fact, due to bias or oversight in the NVUM methodology (discussed further below), the disproportion is far greater than NVUM data indicates. National data shows that snowshoeing and backcountry skiing are two of the fastest growing sports, increasing at rates far greater than the increase in snowmobiling. This is good for public health and the environment, and should be facilitated and encouraged.

#4-14

It is often pointed out that areas designated as Wilderness are closed to all motor vehicles, including OSVs. However, Wilderness areas are frequently located deep in the national forests, far from plowed trailheads and particularly difficult to access in winter. Also, Wilderness areas generally have more mountainous terrain, suitable for telemark or AT skiing but not well-suited to cross-country touring or novice travel. They simply do not and cannot meet the current demand for areas reserved for quiet, human-powered recreation *that are readily accessed in winter*.

II. Specific Faulty Statements or Assumptions in the DEIR

1. <u>Alternatives</u>

#4-15

The Agency failed to consider a fair range of alternatives, in part because the Agency failed to recognize that it can influence Forest Service action. The Agency failed seriously to consider the alternative of requiring use of newer and less polluting technology (i.e four-stroke snowmobiles, which generally create far less noise and pollution than two-stroke snowmobiles.) The Agency improperly discounted alternative S.3.3, Funding Restricted Riding Areas only, because it wrongly assumed that it could not influence coordinated action from the Forest Service. The Agency should confer with the Forest Service first, and determine whether the Forest Service would close existing areas to off-trail riding in exchange for continued receipt of grooming funds for such areas. This action would provide better mitigation of the adverse impacts from the program.

#4-16

In addition, the Agency failed to consider an alternative that recognizes the de facto winter recreation management plan the program creates on National Forest lands. The Agency is essentially crafting a winter recreation plan for National Forest lands in California without adequate public comment or process. The Forest Service has a duty to manage motorized oversnow vehicles in such a way as to minimize impacts to water, wildlife, vegetation, and other resources, as well as to other recreational uses (proposed and existing). See Executive Order No. 11644 as amended by Executive Order No. 11989. It is inappropriate for the Agency to continue with its extensive grooming program – or to expand such program -- until the Forest Service through a public planning process determines winter allocations compliant with the Executive Order direction.

#4-17

2. Area of Controversy

The primary issue of concern raised by these comments is NOT the environmental effects of snowmobiles in general. The primary issue raised by these comments is the environmental effect of the Agency's grooming program itself in disproportionately encouraging the monopolization of winter recreation in California by snowmobiles. The grooming program actively promotes the growth of snowmobiling, and unfairly restrains the growth of quiet winter recreation such as skiing and snowshoeing.

#4-18

3. Baseline

The Agency wrongly applies conditions that exist under its current OSV program as the appropriate baseline for consideration of the impacts from continuation of such program. This is inappropriate bootstrapping.

#4-19

4. Growth in Winter Recreation

The Agency seriously and systematically underestimates the demand for nonmotorized winter recreation. The Agency determines the growth in the sport of snowmobiling by the increase in the number of registered snowmobiles, but determines the growth in nonmotorized winter recreation by the increase (or decline) in sales of Sno-Park permits. This gives a seriously flawed result. The decline in sales of Sno-Park permits may be due to several reasons, including perhaps a sentiment that cross-country skiing and snowshoeing on our national forests ought to be free, *like snowmobiling on our national forests is free.* In fact, national winter recreation trends show a substantial growth in the sports of cross-country skiing and snowshoeing, *each by over 20% a year*.

NVUM and other usage figures understate human-powered recreation because they overlook two newly popular winter sports. Historically, participants in these sports were not counted because they were so few. One of these activities is backcountry skiing using skins, lightweight wide skis and Alpine Touring (AT) bindings. Previously, this sport had been pursued by backcountry telemark skiers, but today AT skiers outnumber the "old school" telemark skiers. According to SnowSports Industries America, sales of AT skiing gear increased 60% from 2007 to 2009.[3]

The second sport is backcountry snowshoeing, which is increasing at an equally dramatic pace. Nationally, snowshoeing increased an incredible 43% in just two years, from 2007 to 2009.[4] *NVUM data has not tracked snowshoeing, a sport which has rapidly grown in only the last five years.* The popularity of these two sports – and the rapid increase in the number of new winter recreationists recreating in this manner – is obvious to anyone who spends time forest lands in winter. In contrast to the rapid growth in human-powered winter recreation, the Outdoor Foundation's 2009 survey shows that snowmobiling is in decline, with a 3.1% decrease in participants from 2007 to 2008.[5]

[3] From $5.2 million for the 2006-2007 season to $8.6 million in the 2009-2010 season.

[4] Data collected by The Physical Activity Council and reported in "Outdoor Recreation Participation Top Line Report 2010" available at www.outdoorfoundation.org.

[5] Outdoor Foundation, Outdoor Recreation Participation Report, 2009 at page 46.

#4-19

The Agency's blindness to the growth in these sports (as well as the resurgence of cross-country skiing and skate skiing), allows it to make this disingenuous statement: "Given the downward trend in day permit purchases, projecting an increase in non-motorized recreation use levels at sno-parks…is tenuous."[6] The Agency needs to look behind this statement and understand what is really occurring. The demand for cross-country ski and snowshoe areas is not being met by the sno-parks, while the Agency's OSV program continues to encourage the growth in snowmobiling opportunities at the expense of cross-country and snowshoe opportunities.

5. Intrusion into Closed Areas and Enforcement

#4-20

The DEIR notes that snowmobiles using the program's trailheads trespass into areas closed to OSV use (generally Wilderness areas) The Agency wrongly relies on mitigation measure LU-1 to render the impact of this trespass insignificant.

The Agency underestimates the severity of the trespass and, without foundation, assumes that a reference to Forest Service enforcement efforts— which are universally underfunded and inadequate— somehow will provide adequate mitigation.

Snowlands Network and Winter Wildlands Alliance receive many comments from their members complaining about the effects of illegal snowmobile use on their most treasured recreation experiences. The most virulent letters go something like this: They describe the members' desire to ski in clean and quiet areas, without noise and pollution from snowmobiles. They describe the hours of effort in traversing by one's own power miles of snow-covered terrain to reach the Wilderness. They describe the skier's joy at finally reaching the slopes he wants to ski in the Wilderness, finally free from motorized intrusion. And then they describe the skier's utter rage and disappointment at finding the slope tracked up by trespassing snowmobiles and the serenity of the Wilderness shattered. All that effort – perhaps weeks in anticipation and planning for the full-day or multi-day excursion -- only to feel at the end that one has been robbed. It may be that only a small percentage of snowmobilers engage in trespass, but the fact is trespass continues. Trespass is frequently witnessed. Trespass is a serious and substantial problem.

The Forest Service recognizes this problem but simply does not have the manpower to stop trespass through enforcement. The boundaries between open areas and wilderness are not readily monitored from the road; they are generally miles from the road, deep in the forest. The few individuals who are caught in the act of trespass often escape or are not prosecuted; they are a small handful of the actual trespassers in any event. The budget for enforcement needs to be increased a multiple of times before it would be a truly effective mitigation measure…and broader zones need to be closed to motorized vehicles so that some enforcement can occur simply by monitoring roadways.

The Agency legally may not take credit for mitigation that is not happening, simply by declaring mitigation to be the responsibility of another agency. It is arbitrary and capricious for

[6] DEIR 2.7.2.2

the Agency to assert – as it does in section 3.3.2.2, that its referral of the trespass program to the Forest Service will "ensure" that trespass remains "less than significant".

6. Air Quality, Energy and Greenhouse Gases.

#4-21 The DEIR states "With the uncertain future emissions restrictions, fleet mix, user acceptance, and rate of phase out of older equipment, it is difficult to predict what in-use OSV emissions will be over the next 10 years." (DEIR 4.1.3.3) This statement also is disingenuous. Such emissions will almost certainly remain unacceptably high unless action is taken to reduce snowmobile emissions. Snowmobiles emit pollution to a larger degree than most other vehicles. The EPA has noted that a two-stroke snowmobile can emit as much hydrocarbons and nitrogen oxides as almost 100 cars and create up to 1,000 times more carbon monoxide.[7] The Agency's own pollution estimates show that the OSV use from the program pollutes more than 100 times the amount of hydrocarbons as are emitted from users driving their vehicles to the trailhead. (DEIR, table 4.11)

#4-22 In order to give a fair environmental review, the DEIR must compare existing restrictions on snowmobile emissions to existing restrictions on passenger vehicle car emissions to indicate the relative significance of snowmobile emissions. The Agency must consider whether the relative pollution contributed by this form of transport, as compared to other forms of transport , is itself a significant impact.

#4-23 The Agency's assumptions regarding future composition of snowmobile fleets is undisclosed and, on information and belief, arbitrary and capricious. The Agency must reveal its projected fleet assumptions and explain their basis in fact. The Agency must also show estimates of future pollution assuming no changes in the relative composition of fleets between older two-stroke and newer four-stroke technology.

#4-24 The Agency fails to adequately consider the impact of OSV air pollution on other users. Snowmobile exhaust lingers on OSV trails, rendering them an unhealthy environment for the aerobic sports of skiing and snowshoeing. Human-powered recreationists must traverse through clouds of snowmobile emissions at and close to trailheads, which exposes individuals to far greater levels of air pollution than they normally encounter. The levels of air pollution prevalent at trailheads should be measured and compared to existing standards for clean air, including under OSHA and other rules affecting workplace conditions.

#4-25 The Agency must adopt policies, including selected prohibition of older technology or altered machines, in order to mitigate this and other impacts of OSVs.

7. Biological Resources; Hydrology and Water Quality.

#4-26 Here and in other areas, the Agency assumes the Forest Service has considered the impacts of its OSV grooming program when, in fact, the Forest Service has not. The Forest Service has not determined to manage snowmobiles with respect to the significant environmental issues noted in the DEIR. The Forest Service does not even conduct an environmental

7 Environmental Protection Agency. 2002. Environmental Impacts of Newly Regulated Non-road Engines: Frequently Asked Questions. Office of Transportation and Air Quality.

assessment regarding its implementation of the OSV Program, relying instead on a categorical exclusion which avoids an analysis of impacts.

#4-27

The Agency also makes several statements and determinations that are not rooted in sound science or evidence. The Agency notes that "Most scientific studies looking at snowmobile effects on wildlife populations were conducted many years ago when snowmobile technology was in its infancy and available speeds were much lower than the high speeds that the current snowmobile models can attain." (DEIR 5.3.3.1 et al) But this statement is belied by the fact that the Agency itself continues to use and reference these studies. In fact, some evidence indicates a much larger impact from snowmobiles than shown by earlier studies. Due to the ability of today's machines to travel large distances and access remote terrain, and the fragility of the mountain environments in which they operate, the Agency must give these issues closer consideration. Petitioners will separately provide the Agency a discussion of the impacts of snowmobiles as documented by scientific studies, to be included as an Exhibit to these comments.

#4-28

In addition, the Agency has apparently measured the relative soil compaction caused by snowmobiles by dividing their weight by their surface area and comparing such impact to comparable measurements for humans, etc. (DEIR table 6-2) This analysis ignores the fact that snowmobiles can be travelling at speeds over 60 mph and often are engaged in jumping, carving and deep cut turns by more advanced riders as well as simply riding up and down across varied terrain, where the impact to the ground depends on one's speed. Snowmobiles have a far greater compressive effect on the soil than the Agency has assumed – perhaps not when cruising flat trails, but when high-marking, riding hard over rough terrain and crossing dips such as stream courses.

#4-29

As with the other mitigation efforts described in the DEIR, the Agency must provide for (i) verifiable reporting of the success of the mitigation efforts and (ii) an automatic suspension of grooming activities in the event impacts are occurring at a level that is more significant than the Agency has assumed in the DEIR.

8. <u>Noise.</u>

#4-30

One need not make technical noise measurements to recognize that the typical snowmobile creates a huge amount of noise – comparable to aircraft. The noise of most snowmobiles destroys the quiet recreational experience of other users within a mile - or several miles - of the snowmobile. The Agency capriciously discounts the problem of snowmobile noise in several ways.

First, the Agency determines that by definition the problem does not exist. Throughout its review, the Agency notes that its OSV program areas are intended for snowmobile use and, accordingly, other users are on notice that snowmobiles will be there. Thus, the impact of snowmobiles is negligible. In the words of the Agency, "Nonmotorized users of the trail system know in advance that OSV use occurs on and off the trails in the Project Area and that project trails do not offer protection from intrusive sights of sounds of snowmobiles." (7.3.2.1) *If giving people notice of noise were a sufficient justification to allow noise pollution, there would never be noise pollution.* Most offensive sources of noise are well-known, recognized and highly

#4-30 predictable in their recurrence. This tautology is not justification or mitigation. The Agency further ignores the fact that there simply are NOT accessible alternative areas where many of these skiers and snowshoers can pursue their sport free from the noise of motorized vehicles.

#4-31 Second, the Agency willingly ignores the actual level of snowmobile noise. The Agency concludes that a 73 db level of noise is insignificant (7.3.2.2), but in fact – as the Agency recognizes elsewhere - snowmobile noise is far greater than 73 db. *73 db is a voluntary standard for snowmobiles travelling essentially at idle power* and the Agency recognizes that many users alter their vehicles to increase power, violating even the higher legal standard of 82 db. It would appear that the Agency has made no effort to determine actual noise levels prevalent at its program locations! Snowmobile noise levels can be casually assessed by standing on roadways adjacent to areas of snowmobile activity. It is readily apparent that snowmobiles in fact create *far greater* noise than passenger vehicles travelling on highways.

#4-32 Third, the Agency wrongfully assumes that the winter landscape deadens the transmission of noise when, in fact, due to the cold air, the often hard surface of the snowpack in typical Sierra Nevada conditions, the smooth surface of the snowscape and its coverage of native shrubs, the Sierra Nevada winter landscape is *particularly susceptible* to noise pollution. As is apparent to any winter user, snowmobile noise travels *much farther* than the half mile generally assumed for OHV vehicle noise in summer.

#4-33 Fourth, the Agency wrongly assumes that the Forest Service is addressing this issue through its zoning powers. The Agency states that "OSV use is restricted to specific trail locations in order to minimize conflicts between uses." (DEIR 7.3.2.1) This simply is not true. There are relatively few areas outside of Wilderness where snowmobiles are restricted in the Sierra Nevada national forests.

#4-34 Fifth, the Agency wrongly assumes that because the Forest Service has not set noise limits on OSVs, then the noise impacts must be insignificant. (DEIR 7.3.2.1, et al)

8. <u>Recreation Conflicts</u>

#4-35 The Agency wrongly assumes that recreation conflicts are being addressed by the Forest Service through motorized travel plans and OSV regulations (DEIR 8.1.4). This is not true. In fact, many national forests are intentionally deferring consideration of the impact of snowmobiles, and snowmobile restrictions and prohibitions, due to the snowmobile non-rule, 36 C.F.R. 212.81.

#4-36 The Agency wrongly relies on Sno-Park sales data and NVUM data to indicate user demand when it is apparent that these sources understate skier and snowshoer visits and demand. (DEIR 8.2.1) Sno-Park data indicates only the success of the Sno-Park program, and indicates only that the Sno-Park program is NOT meeting current demand. NVUM data – which as quoted by the Agency shows skier visits outnumber snowmobiler visits, still significantly understates the current number of skiers and snowshoers for several readily apparent reasons. The NVUM program has generally not tracked the numbers of snowshoers because this sport is new as a popular winter activity. The NVUM data also does not appear to track the number of backcountry skiers, who consider their sport very different from "cross-country skiing" and who

#4-36

– due to the relative paucity of trailheads that serve their needs, often are not counted in NVUM surveys. Even if backcountry skiers or snowshoers were counted as "cross-country skiers," in the NVUM data, most of the data simply does not reflect the recent rapid growth of backcountry AT touring and of snowshoeing. These sports have blossomed in recent years due to a variety of factors, including more advanced gear and a watershed recognition of snowshoeing as a mainstream winter sport. In addition, in recent years, the sport of cross-country skiing has undergone a resurgence with the growth in popularity of skate skiing, which is particularly suited to the Sierra Nevada with its long spring season with hardened surface conditions.

Industry sales figures provide a reliable indication of the rapid growth in the sport and the recent increase in users. According to SnowSports Industries America, sales of AT skiing gear increased 60% from 2007 to 2009, despite the recession.[8] The Physical Activity Council only started tracking AT touring as a distinct sport in the 2007-2008 season and its data shows an 11.6% growth in AT touring in the next year, 2008-2009.[9] Telemark skiing also continues to grow at a rapid pace, with the Outdoor Foundation reporting a 22% growth from 2007 to 2008.[10]

Although it has been ignored by NVUM surveys, snowshoeing has recently had watershed recognition as a mainstream winter sport. According to The Physical Activity Council, the sport of snowshoeing increased an incredible 43% in two years, from 2007 to 2009.[11] The Outdoor Foundation likewise reports a 22% growth in snowshoeing in the one year from 2007 to 2008.[12] Also, according to SnowSports Industries America, in just three seasons, from 2007 to 2010, sales of snowshoe equipment increased <u>97%</u>.[13] Tahoe area cross-country ski resorts have recently recognized this new sport, adding snowshoe rentals and tours to their business.

Cross country skiing has also undergone dramatic recent change and growth. According to The Physical Activity Council, cross country skiing increased 17.8% in just two seasons, from 2007 to 2009.[14] The California mountain snowscape is in many respects ideally suited to be a mecca for cross-country skiing. The newly popular sport of skate skiing generally requires groomed conditions. But, due to the rapid settling of the maritime snowpack, backcountry skate skiing is often feasible in the California mountains. This sport is destined to grow substantially as more people appreciate its possibilities and will create increased demand for quiet areas untracked by snowmobiles.

#4-37

The Agency wrongly assumes that "in practicality steep terrain, lack of snow, and poor access substantially limit areas available to OSV use." (DEIR 8.2.2) Whereas this statement might have been true twenty years ago, it is no longer true today, as further described above.

[8] From $5.2 million for the 2006-2007 season to $8.6 million in the 2009-2010 season.
[9] SIA email to Snowlands Network.
[10] Outdoor Foundation, Outdoor Recreation Participation Report 2009, at p. 10.
[11] Data collected by The Physical Activity Council and reported in "Outdoor Recreation Participation Top Line Report 2010" available at www.outdoorfoundation.org.
[12] Outdoor Foundation, Outdoor Recreation Participation Report 2009, at p. 10.
[35] SIA email to Snowlands Network.[14] Data collected by The Physical Activity Council and reported in "Outdoor Recreation Participation Top Line Report 2010" available at www.outdoorfoundation.org.
[14] Data collected by The Physical Activity Council and reported in "Outdoor Recreation Participation Top Line Report 2010" available at www.outdoorfoundation.org.

#4-38 In finding no significant conflict with nonmotorized users, the Agency continues to rely on the 73 db noise level voluntary standard, even though this standard is irrelevant: it is a voluntary standard a snowmobile travelling at 15 mph, which is little more than idle for today's powerful machines. The Agency recognizes that this standard is irrelevant and yet uses it anyway. (DEIR 8.3.2.3)

#4-39 Throughout its discussion of recreation, the Agency continues to rely on the bootstrap argument that conflict is irrelevant because nonmotorized users know snowmobiles will be present, and on the false assumption that the Forest Service is providing a proportionate amount of areas reserved for and accessible to nonmotorized users. The fact is, nonmotorized users do NOT want to recreate in areas frequented by snowmobiles. They recreate in such areas only because the Forest Service does not make proportionate lands available for nonmotorized users to be free from motorized traffic. In analyzing the environmental impact of its program, the Agency needs to consider these realities.

III. Necessary Changes and Mitigation

#4-40

1. <u>Increase in Trailheads Reserved for Clean and Quiet Recreation</u>

In order to mitigate the significant adverse impacts of its program, the Agency needs to contribute funding to the creation of trailheads reserved for human-powered winter recreation, and cause the Forest Service to protect such areas from motorized travel. In some cases, this may be accomplished by dedicating existing Sno-park or OSV program locations to clean and quiet recreation, or by dividing existing locations into areas where OSV travel is permitted and areas where OSV travel is not permitted. In other locations new trailhead locations must be established, largely through dedicated funding of additional existing but unplowed trailhead locations. The Agency OSV Program must be made dependent on such mitigation measures creating a balance of opportunities for winter recreation in California.

#4-41

2. <u>Restrictions on Older Technology</u>

In OSV program areas where there is significant skier and snowshoer traffic, or significant demand for clean and quiet recreation opportunities, the Agency must restrict or require the Forest Service (as a condition to the receipt of grooming funds) to restrict the continued use of snowmobiles that emit substantial exhaust or substantial noise. Generally, this would require the use in these areas of newer generation snowmobiles (e.g. four-stroke engines) that have not been altered to increase performance or noise levels.

The Agency may not reject this alternative as beyond the scope of the OSV Program. The Agency is required to mitigate the effects of its program, and restricting the types of vehicles that may be used in an area is a well-established mitigation measure. The impact on owners of older technology equipment can be minimized by phasing the restrictions in over the program areas over a period of time.

3. <u>Additional Funds for Enforcement</u>

#4-42

The Agency needs to dedicate substantial additional funds to enforcement efforts and work with the Forest Service to improve enforcement against trespass by designating large areas as nonmotorized, where enforcement can be provided in part by monitoring roadways. This is particularly important in the vicinity of Wilderness.

4. U.S. Forest Service Recreation Plan Needed

#4-43

As noted above, the Forest Service has a duty to manage motorized oversnow vehicles in such a way as to minimize impacts to water, wildlife, vegetation, and other resources, as well as to other recreational uses (proposed and existing). See Executive Order No. 11644 as amended by Executive Order No. 11989. It is inappropriate for the Agency to continue with extensive grooming operations – and especially to begin planning for new trailheads devoted to this program-- which establishes de facto winter recreation allocations on National Forest lands, until the Forest Service through a public planning process determines winter allocations compliant with the Executive Order direction. The planning process must be spearheaded by the Forest Service as the land manager, but could be conducted in cooperation with the Agency.

Petitioners would appreciate the opportunity to meet with the Agency to further discuss their concerns in a cooperative manner.

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Appendix C

ENVIRONMENTAL IMPACTS FROM OVER-SNOW VEHICLE USE

Scientific evidence indicates significant OSV impacts on animals, plants, soils, air and water quality, and the ecology of entire winter ecosystems. OSV impacts to wildlife and wildlands represent a negative cycle where one impact leads to and compounds the next, and where the synergistic impacts cascade into major, long-term, and potentially cumulative adverse impacts. While the severity of OSV impacts will differ depending on the site-specific characteristics of an area, OSV use clearly impacts any winter ecosystem on which it occurs.

Soil and Vegetation Damage

Over Snow Vehicles cause significant damage to land cover through direct physical injury as well as indirectly through snow compaction. Impacts on soil and vegetation include retarded growth, erosion, and physical damage (Baker and Bithmann, 2005). These impacts are exacerbated on steep slopes (Stangl, 1999) or in areas with inadequate snow cover (Stangl, 1999; Baker and Bithmann, 2005). This erosion can lead to increased soil runoff resulting in sedimentation and turbidity in the immediate area and throughout the watershed (Stangl, 1999). Rongstad (1980) reported delayed flowering in some plants in spring, lower soil bacteria, and elimination of some plants due to snow compaction.

Snow compaction from snowmobiles can lower soil temperatures and reduce the survival of plants and soil microbes (Wanek, 1973). A natural, un-compacted snowpack greater than 45 cm deep will prevent frost from penetrating the soil (Baker and Bithmann, 2005). However, the thermal conductivity of snow, when compacted by snowmobiles, is greatly increased, resulting in both greater temperature fluctuations and overall lower soil temperatures (Baker, and Bithmann, 2005). This in turn inhibits soil bacteria that play a critical role in the plant food cycle (Stangl, 1999).Thus the growth and reproductive success of early spring flowers is retarded and reduced (Wanek, 1973). Packed snowmobile trails can also dilute important sunlight “cues” that filter down to subnivean plants and stimulate them to grow or reproduce (Canadian Wildlife Federation, 1998). Additionally, the timing of snowmelt determines the distribution of plant communities in subalpine zones, so delays in spring growth caused by snow compaction from snowmobiles can cause drastic changes in subalpine plant communities (Biodiversity Conservation Alliance, 2002).

Vegetation in riparian areas is highly susceptible to damage from snowmobiles (Stangl, 1999).
In their study of snowmobile impacts on old field and marsh vegetation in Nova Scotia, Canada, Keddy *et.al.* (1979) concluded: Compaction may affect the soil surface microstructure, which Harper *et. Al.,* (1965) have shown will greatly determine the suitability of a site for seed germination. Compaction of the previous year’s vegetation and/or spring snow retention may also affect early spring germination and growth. Compaction of vegetation may affect seed dispersal from capsules still attached to dead

stalks. And finally, snow compactions may modify seed predation patterns by subnivean rodents. In his study of the effects of snowmobile activity on wintering pheasants and wetland vegetation in Iowa, Sojda (1978) revealed that snowmobiling caused a 23 percent decrease in cattail density, 12 percent decrease in cattail height, and a 44 percent increase in *Carex* density. These changes were believed to be caused by a change in gas exchange as a result of the cutting and submerging of litter by snowmobile activity.

When snowmobiles are riding over the snow, abrasion and breakage of seedlings, shrubs, and other exposed vegetation is common (Stangl, 1999). Neumann and Merriam (1972) showed that direct mechanical effects by snowmobiles on vegetation at and above snow surface can be severe. After only a single pass by a snowmobile, more than 78 percent of the saplings on the trail were damaged, and nearly 27 percent of them were damaged seriously enough to cause a high probability of death. Young conifers were found to be extremely susceptible to damage from snowmobiles. Wanek (1971a), in a study in Minnesota, reported that 47 percent of pines and over 55 percent of white spruce sustained damage by snowmobiles traversing his study site. In 1973, with reduced snowfall, Wanek (1973; undated) documented that 92.6 percent of white spruce were damaged, with 45.4 percent receiving heavy damage and 8 percent perishing altogether within his snowmobile study site. As part of ongoing efforts to evaluate regeneration and thinning needs the Gallatin National Forest conducted regeneration transect surveys of previously logged timber stands. Required by the National Forest Management Act the surveys look for a variety of damage types and causes, including insects, diseases, and recreation. On the 72,393 acres surveyed between 1983 and 1995, snowmobiles damaged between 12 and 720 trees per acre (WWA, 2009) (See Appendix ___). Given the recent petition to list the Whitebark Pine as an endangered species (NRDC, 2008) , and the multiple ecosystem benefits this tree species provides, protection of sub-alpine vegetation from damage such as that caused by OSVs is imperative.

Air and Water Quality

Impacts of OSV use include the degradation of both air and water quality. Two-stroke engines, which represent the vast majority of OSV use on NFS land, are particularly onerous. A two-stroke snowmobile can emit as much hydrocarbons and nitrogen oxides as 100 cars and create up to 1,000 times more carbon monoxide (EPA, 2002).

Two-stroke engines emit dangerous levels of airborne toxins including nitrogen oxides, carbon monoxide, ozone, aldehydes, butadiene, benzenes, and extremely persistent polycyclic aromatic hydrocarbons (PAH).[1] Several of these compounds are listed as "known" or "probable" human carcinogens by the EPA. Benzene, for instance, is a "known" human carcinogen and several aldehydes including butadiene are classified as "probable human carcinogens." All are believed to cause deleterious health effects in

[1] In their study of cars and motorcycles (2 stroke and 4 stroke) with and without catalysts (catalytic converters), Chan et al. (1995) found that noncatalyst vehicle emission contained more volatile organic compounds (VOCs - benzene, heptene, heptane, toluene, ethylbenzene, m/p-xylene, isopropyl benzene) than those emitted by catalyst vehicles while two-stroke engines emitted more VOCs than four stroke engines.

humans and animals well short of fatal doses (EPA 1993). In addition, two-stroke engines also discharge 25-30 percent of their fuel mixture unburned directly into the environment (Blue Water Network 2002). Unburned fuel contains many toxic compounds including benzene, toluene, xylene and the extremely persistent suspected human carcinogen Methyl Tertiary Butyl Ether (MTBE). Winter recreationists are especially at risk because the concentration of these emissions increases with elevation and cold (Janssen and Schettler, 2003).

Clean Air Act

the United States government has enacted a series of air quality acts, beginning with the Air Pollution Control Act of 1955, and followed by the Clean Air Act of 1963, the Air Quality Act of 1967, the Clean Air Act Extension of 1970, and Clean Air Act Amendments in 1977 and 1990. These acts require the U.S. Environmental Protection Agency to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. Air quality standards for snowmobile emissions include carbon monoxide (CO), unburned hydrocarbons (HC), particulate matter (PM), and oxides of nitrogen (NO). As noted below, snowmobiles produce significant emissions including CO, HC, PM, and NO (Morris *et. al.,* 1999). In heavily traveled snowmobile use areas, snowmobile emissions likely exceed National Ambient Air Quality Standards.

In 2007, the U.S. Supreme Court ruled that carbon dioxide (CO_2) is an "air pollutant" under the Clean Air Act and that the Environmental Protection Agency (EPA) can regulate CO_2 emissions from motor vehicles (Greenhouse, 2007). Since then, states also have begun to assert independent authority to require consideration of climate change in environmental impact assessments (Grant and Webber, 2007). Future compliance to the Clean Air Act and NEPA will likely require consideration of carbon dioxide emitted by snowmobiles, as evidenced by recent proposals from both CEQ (Sutley, 2010) and EPA (EPA, 2008).

Carbon Monoxide

Dangerous levels of carbon monoxide (CO) and particulate matter (PM) are a primary concern. CO is extremely dangerous to humans (discussed below), and particulate matter is a recently confirmed human carcinogen by the Environmental Protection Agency. Snowmobiles emit dangerously high levels of carbon monoxide. A study conducted for the National Park Service in 1997 concluded that a single snowmobile produces 500-1000 times more carbon monoxide than a 1988 passenger car (Fussell-Snook 1997).[2]

[2]Notably, comparisons to a current model-year passenger vehicle would increase this figure significantly. Some modern cars emit only .12 grams/kW-hr as compared to CARB estimates of 1078 grams/kW-hr for snowmobiles. As a result, some snowmobiles produce almost 9,000 times more carbon monoxide during a given period than a modern car.

Due to the popularity and proliferation of snowmobile use in West Yellowstone during the 1990's, the Park Service conducted air quality studies under various conditions at the West Entrance. The park used stationary and mobile testing apparatus in 1995 and 1996, focusing on carbon monoxide (CO) and particulate matter concentrations at ground level. Preliminary results indicate that CO levels exceed federal and state ambient air quality standards at certain times.[3] In fact, a reading of 36 ppm in 1996 was the highest concentration recorded for CO nationwide, including cities with notoriously high CO levels such as Los Angeles and Denver. Results from both years demonstrate a positive correlation between snowmobile density and high CO levels.

Carbon monoxide is also dangerous because it binds to the hemoglobin in blood (forming carboxyhemoglobin) and renders hemoglobin incapable of transporting oxygen (Fussell-Snook 1997). Elevated levels of carboxyhemoglobin can cause neural-behavioral effects at low levels (2-3 percent), headaches and fatigue (10 percent), and respiratory failure and death at higher levels. CO is particularly hazardous during pregnancy, and to the elderly, children, and individuals with asthma, anemia or other cardiovascular disease (EPA, 1994).[4]

Polycyclic Aromatic Hydrocarbons

PAHs are by-products of fuel combustion found in high concentrations in unregulated two-stroke emissions. They are particularly hazardous because they are both carcinogenic and mutagenic, and are extremely persistent in the environment. In a study of snowpack contamination by snowmobiles Matthew R. Graham of the University of Nevada-Reno found elevated readings of four PAHs -- acenapthene, acenaphylene, napthalene and phenanthrene -- in snow samples under field conditions. Graham detected levels of napthalene, for instance, of up to 12,000 ppb. According to the Occupational Safety and Health Administration (OSHA), the short-term human exposure limit (STEL) for napthalene is 15,000 ppb. OSHA's Health Hazard Data indicates that "contact may cause skin or eye irritation ... inhalation may cause headache, nausea and perspiration ... [and] ingestion may cause cramps, nausea, vomiting and diarrhea" (OSHA 1996).

Methyl Tertiary Butyl Ether

Methyl Tertiary Butyl Ether (MTBE) is a controversial fuel additive and suspected carcinogen. Although the additive is commonly regarded as a hazard to drinking water from underground storage tanks, fuel spills, snowmobiles and other OSVs are a significant source of MTBE.

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[3]Federal standards for CO are 35 and 9 parts per million for a one and eight hour average, respectively, 40 CFR § 50.8(a)(1)(2). State standards differ for Montana and Wyoming. In Montana, the CO standards are 23 and 9 ppm for the 1 and 8 hour averages, respectively, while Wyoming's standards are identical to those of the federal government.

[4]For a summary of the human health effects of snowmobile pollutants, including carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter, see EPA (1994).

MTBE is a concern in snowmobiles and other OSVs for two reasons: 1) because these vehicles spill large quantities of unburned fuel into the environment, up to 15% of which is MTBE; and 2) because these vehicles produce very high emissions containing carcinogenic MTBE combustion by-products.

Although no studies have addressed wild animal sensitivity to MTBE in the environment, humans are extremely sensitive to the chemical. The Association of California Water Agencies reports that humans can consistently smell the chemical in the water at 15 ppb (Pirnie 1998). Only one-third of a gallon of MTBE is required to bring the drinking water consumed daily by 90,000 people to a contaminant level of 15 ppb. It is therefore safe to assume that even small amounts of raw MTBE from snowmobile exhaust leaching into snowpack and watersheds within National Forest boundaries should be considered a threat to the quality of Forest water and snow resources, with perhaps more serious implications for wildlife.

More research is needed on the suspected human health risks of MTBE,[5] but EPA confirms that in laboratory animals a lifetime exposure to MTBE in air causes cancer. Animals exposed to small amounts to MTBE show kidney damage and other adverse effects on the developing fetus.[6] The toxic effects of MTBE on micro-organisms, marine life, and vegetation have also not been extensively studied. According to preliminary reports from researchers at the University of California at Davis, MTBE is acutely toxic to various aquatic organisms at concentrations as low as 44 parts per billion (ppb), and bacterial assays are most sensitive in terms of toxicity measured at 7.4 ppb over a relatively short 48 hour period.

The combustion byproducts and human metabolites of MTBE are also a concern for snowmobilers and other recreationists exposed to snowmobile emissions, and may be a concern for the environment. MTBE reacts with natural oxygen and hydrogen molecules in the air to form tertiary butyl-formate (TBF), an extremely destructive compound to tissues of mucous membranes and the upper respiratory tract. MTBE combustion also increases airborne concentrations of formaldehyde, an EPA-listed "probable" human carcinogen and a confirmed immune system suppressant. Peter Joseph, Professor of Radiologic Physics at the University of Pennsylvania School of Medicine, believes that

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[5] According to reports, however, the acute toxicity of MTBE is comparable to the known human carcinogen and reproductive toxin benzene. Dr. Myron Mehlman, an adjunct Professor of Public Health at the Robert Wood Johnson Medical School and editor of Toxicology and Industrial Health, believes that research shows that MTBE is a human carcinogen, causing the same cancers in laboratory animals as benzene, and at the same dosage levels (Bluewater Network 1999 citing personal communication with Dr. Mehlman). Considering that the EPA requires reporting of any benzene spill exceeding one pound due to its highly toxic properties and that snowmobiles, as previously reported, dump a pound of unburned MTBE into the environment every 1-2 hours, the presence of MTBE in gasoline as a highly water soluble and persistent suspected carcinogen, with projected yet unstudied effects on water and aquatic life, exacerbates the threat of significant air and water emissions from snowmobiles.

[6] EPA MTBE information obtained from the agency's Drinking Water Contaminant Candidate List (CCL), (http://www.epa.gov), June, 1998.

these byproducts of MTBE are responsible for creating major public health problems, including an explosion in asthma beyond anything experienced in human history (Bluewater Network 1999 citing a personal communication with Dr. Joseph). EPA also confirms that the human metabolites of MTBE are tertiary-butyl alcohol (TBA) and formaldehyde. TBA is listed as "harmful or fatal if swallowed," and also suppresses the immune system. In Wilmington, North Carolina, every one of 175 patients tested was found to have MTBE in their blood which resulted in significant immune system suppression (Bluewater Network 1999 citing a personal communication with Dr. Joseph).

Ozone

Pollutants generated by OSVs not only contain dangerous levels of airborne toxins, but can lead to the formation of additional ground level ozone from the photochemical reaction of released nitrogen and hydrocarbons. Health risks associated with exposure to smog and nitrogen include respiratory complications such as coughing, chest pain, heart problems, asthma, concentration lapses and shortness of breath. Elderly individuals and children are particularly sensitive to ground level ozone and nitrogen.

Aquatic and Terrestrial Impacts

Pollutants from snowmobile emission, including the highly persistent PAHs, are stored within the snowpack (Ingersoll, 1998). During spring snowmelt, these accumulated pollutants are released causing elevated acidity levels in surrounding waterways and resulting in higher death rates for aquatic insects and amphibians (Charette *et. al.,*,1990). The impact of the spring release of pollutants may have far-reaching consequences for surrounding watersheds. Acidity fluctuations can disable a watershed's ability to regulate its own pH level, which could trigger system-wide problems and result in a long-term alteration of an entire ecosystem (Shaver *et. al.,*, 1998).

The direct deposition of unburned fuel into the environment represents a substantial impact caused by OSVs. As previously noted, two-stroke engines release more than 25 percent of their fuel unburned into the environment. A 2001 survey of snowmobilers in Wyoming revealed that on average snowmobilers use more than 11 gallons of fuel per visit (McManus, 2001). There are an estimated 340,200 annual snowmobile visits to Wyoming's Bridger Teton National Forest (National Visitor Use Monitoring data). By overlaying the daily fuel consumption on the estimated annual snowmobile visits it appears that each winter snowmobiles discharge more than one million gallons of unburned fuel into the Bridger-Teton National Forest. If extrapolated across the Snowbelt NFS lands, the amount of unburned fuel discharged directly into the snowpack by OSV use is staggering.

While two-stroke engines have since been banned in Yellowstone National Park (one of the only such bans in the U.S.), during the 1990's when two-stroke engines were in use, toxic raw fuel and air emissions accumulated in Yellowstone's snowpack along rivers, streams and lakes and roads where snowmobile use occurred. Ingersoll *et. al.,* (1997) found increased levels of sulfates and ammonium in Yellowstone's snowpack compared to baseline conditions.[7] Pollutants "locked" in the snowpack are released very rapidly during the first few days of snow melt. Researchers found that 80 percent of acid concentrates are released in the first 20 percent of snowmelt, and that this acid pulse is a major cause of death for aquatic insects and amphibians (Rawlins 1993, Hagen and Langeland, 1973). This acid pulse may also reduce the acid neutralizing capacity of aquatic systems, particularly those found at high elevations which typically are less capable of neutralizing acid deposition.[8] In one study, Charette et al. (1990) determined that "during the spring melting, the massive liberation of atmospheric pollutants accumulated in the snow cover is connected to a very important increase of acidity, which may be more than 100 times higher than the usual acidity level in surface water."

Several studies have determined that the survival, productivity, and distribution of amphibians are drastically impacted by increasing acidity (Cooke and Frazier 1976, Beebee and Griffin 1977, Saber and Dunson 1978, Freda and Dunson 1985). Kiesecker (1991), for example, found that 60-100 percent of tiger salamander eggs were dead or unviable in ponds at pH 5.0 or less, 40 percent were dead or unviable at pH levels between 5 and 6, and 20 percent were dead or unviable in water with a pH above 6.0. At pH levels below 6.0, a slower hatching rate, slower growth to maturity, and a decreased ability of tiger salamanders to catch and eat tadpoles was observed. Pierce and Wooten (1992) also documented sublethal effects of lowered Ph on amphibians (e.g., slower growth of larvae) above the levels that kill embryos. Increased acidity also may cause amphibians to avoid breeding in low pH ponds (Beebee and Griffin 1977).

Harte and Hoffman (1989) studied a declining tiger salamander population in an acid-sensitive watershed in the Colorado Rockies and concluded that less than half as many tiger salamander embryos survived at about pH 5.6 or less compared to those surviving at about pH 6.1 or greater and that survival of zooplankton, a common food of the tiger salamander, was also drastically affected by increased acidity. Furthermore, they found that only a brief exposure to acid is needed to induce amphibian mortality, that acidified water resulted in developmental abnormalities, and concluded that episodic acidification may have contributed to the salamander population decline.[9] Based on their results, Harte and Hoffman (1989) theorized that there are at least five possible mechanisms by

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[7]Research in the Sierra Nevada in California and the Colorado Rockies has shown that a temporary depression of surface-water pH and alkalinity and a simultaneous increase in sulfate and nitrate levels occurs following spring snowmelt (Blanchard et al. 1987).

[8]Studies conducted in Yellowstone revealed that "many lakes and streams in Yellowstone are susceptible to acidification by atmospheric deposition" (National Park Service 1983). Similarly, in the Forest Service’s Eastside Ecosystem Management Project, it was determined that concentrations of air pollutants in the snowpack “are greatest in Wyoming and in a small area within Montana just west of Yellowstone National Park. Some of the largest concentrations of sulfate, nitrate, and acidity were measured at sites near Yellowstone.” (USFS 1996).

[9]While tiger salamanders have been determined to be particularly sensitive to increased acidity, the impact can effect the entire ecosystem. In Ontario, the artificial acidification of a lane from Ph 6.7 to Ph 5.0 resulted in an increase in biomass and change in species composition of phytoplankton when pH dropped below 6.0 (Findlay and Kasian 1986).

which episodic acidification might reduce the salamander population. It might (1) inhibit egg development, (2) exert a direct toxic effect upon the hatchlings, (3) exert a direct toxic effect upon the adult population, (4) inhibit reproductive activity, (5) damage the food chain (See also, Schindler *et. al.,* 1985). Other amphibians, including boreal toads, chorus frogs, and northern leopard frogs also experience significant mortality when water pH is between 4.3 and 4.9 (Corn and Vertucci 1992).

In a study on the impact of two-stroke emissions on fish, *Balk et. al.,* (1994) determined that hydrocarbons disrupt normal biological functions (e.g. DNA adduct levels, enzyme activity), including cellular and sub-cellular processes, and physiological functions (e.g. carbohydrate metabolism, immune system).[10] Serious disruption of fish reproduction and fry survival also seems likely.[11] (See also, Tjarnlund *et. al.,* 1995, 1996). Baker and Christensen (1991), for example, found that embryo and fry of rainbow trout have increased mortality at about pH 5.5. Adams (1975) also found that the influence of lead and hydrocarbon on stamina, measured by ability to swim against a current, was significantly less in trout exposed to snowmobile exhaust than in control fish; the exposed fish made fewer tries to swim against the current, and swam for shorter lengths of time before resting.[12]

Pollution from OSV exhaust contains a number of elements which are damaging to vegetation. While the amount of pollutants emitted by two-stroke engines are greater than those emitted by four-stroke engines, the elements in the emissions, except for the unburned fuel emitted by two-stroke engines, are similar and include: 1) carbon dioxide which may act as a fertilizer and cause changes in plant species composition (Bazzaz & Garbutt 1988, Hunt et al. 1991, Ferris and Taylor 1995); 2) sulphur dioxide which is taken up by vegetation and can cause changes in photosynthesis (Winner and Atkinson 1986, Iqbal 1988, Mooney *et. al.,* 1988); 3) oxides of nitrogen which may be harmful to vegetation or may act as a fertilizer, causing changes in plant species composition

[10]Additional evidence of such impacts comes from toxicologist James Oris and his colleagues at Miami University who conducted a study on the effects of hydrocarbon pollution from two-stroke marine engines, the exact same engine used by snowmobiles, on fish growth. The study, funded by the National Marine Manufacturers Association, found fish growth to be decreased by as much as 46% as a result of exposure to two-stroke water pollution. Although the study addressed concern about marine engines, snowmobiles are capable of creating similar levels of water pollution in streams, lakes and rivers due to frozen or trapped hydrocarbon pollution in snowpack and polycyclic aromatic hydrocarbon contamination described above.

[11]Juttner, et al. (1995) determined that the toxicity of water contaminated by a two-stroke engine was far higher than contamination caused by four-stroke engine or a catalyst equipped two-stroke engine. Two-stroke engines also emitted significantly more hydrocarbons and volatile organic compounds into the water than a four-stroke engine (Juttner, et al. 1995a). Experiments which replaced gasoline with 96 percent ethanol reduced the persistent toxicity but the toxicity of freshly contaminated water was still high. Modifying the lubricating oils used in the fuel blend, on the other hand, had little effect on toxicity.

[12]It is not clear in Adams (1975) whether the lead or hydrocarbons, or both, reduced the stamina measured in laboratory fish. Lead contamination is not as great a concern currently because of the existence and use of unleaded fuels. Unleaded fuel, however, contains trace amounts of lead which may accumulate in the environment causing adverse environmental impacts.

(Rogers and Campbell 1979, Falkengren-Grerup 1986, Iqbal 1990); 4) organic gases such as ethylene, to which plants may be extremely sensitive (Gunderson and Taylor 1988, Taylor *et. al.,* 1988); and 5) heavy metals which may cause phytotoxic damage (Atkins *et. al.,* 1982). Ozone, which is formed by the photochemical reaction of released nitrogen and hydrocarbons, may also injure plants and affect plant species composition (Reich and Amundson 1985, Becker *et. al.,* 1989, Ashmore and Ainsworth 1995, Warwick and Taylor 1995).

Shaver *et. al.,* (1988) reported that the effects of pollutants can be both biological and ecological, and both acute and chronic. Such effects on plants include foliar injury, reduced productivity, tree mortality, decreased growth, altered plant competition, modifications in species diversity, and increased susceptibility to diseases and pests. Alterations to the vegetative community are also likely to result in implications to herbivores and other ecosystem components. In addition, ingestion by herbivores of trace elements deposited on leaf surfaces may lead to other impacts to the individual organism and throughout the food chain.

The EPA has adopted emission standards for new machines. Unfortunately, several factors serve to reduce their impact and even trivialize them. The standards adopted do not eliminate noxious emissions but only reduce the amount of CO and HC emissions by 50 percent (Rivers and Menlove, 2006). Further, manufacturers have until 2012 to bring their fleets into compliance and they may meet the standards by using "fleet averaging," which means that each manufacturer's production fleet would only have to, on average, meet these emission reductions (NPS, 2000). Some of the models may continue to exceed the standard as long as other models beat the standard. High powered mountain, powder, and hill-climbing snowmobiles – those used in the backcountry–will surely exceed the emissions standard. Additionally, the standard only applies to stock models. Since the aftermarket parts sales are such an important part of a retailer's revenue, it can be expected that many machines will be retrofitted, escaping the standards altogether (Rivers and Menlove, 2006). Finally, all existing snowmobiles are grandfathered into the EPA regulation.

Permitting unregulated use of OSVs on NFS lands fails to safeguard these areas from significant water and air pollution which threaten Forest resources, including wildlife, and Forest users. Such impacts are inconsistent with provisions set forth in the Clean Water Act, the Clean Air Act amendments of 1990, applicable Executives Orders, and USFS regulations and policies.

Noise Pollution

Natural soundscapes are intrinsic elements of the environment and are necessary for natural ecological functioning (Burson, 2008). Noise from snowmobiles severely affects the winter soundscape and impacts both wildlife and other visitors. Animals exposed to high-intensity sounds suffer both anatomical and physiological damage, including both auditory and non-auditory damage (Brattstrom and Bondello1983).

Sounds can occur in both a continuous and intermittent manner. At high intensities, sounds can have a deleterious impact on human hearing if sustained for certain lengths of time (Brattstrom and Bondello 1983). Intermittent sounds or startle noises have been shown to have many effects on humans including annoyance, disruption of activity, increase in heart rate, vasoconstriction, increase in blood pressure, stomach spasms, headaches, stress, fetal convulsions, ulcers, and coronary disease (Baldwin and Stoddard 1973, Brattstrom and Bondello 1983). However, the larger, more sophisticated, better protected human ear is capable of withstanding high intensity sounds which easily damage smaller, more simplistic ears of many species of wildlife (Brattstrom and Bondello 1983) and thus animals may be more affected by noise compared to humans. Thus, a vehicle noise limit acceptable in urban areas may be capable of severely damaging the hearing of exposed wildlife populations (Brattstrom and Bondello 1983).

Indirectly, the noise generated by OSVs can adversely impact animals impairing feeding, breeding, courting, social behaviors, territory establishment and maintenance, increasing stress, and/or by making animals or their young more susceptible to predation (Janssen 1978, Weinstein 1978, Luckenbach 1975, Wilshire *et. al.,* 1977, EPA 1971, Bury 1980, Jeske 1985, Burger 1981, Vos *et. al.,* 1985, Baldwin 1970, Rennison and Wallace 1976). According to the Environmental Protection Agency, noise acts as a physiological stressor producing changes similar to those brought about by exposure to extreme heat, cold, pain, etc. (EPA 1971). The EPA states that:

> Clearly, the animals that will be directly affected by noise are those capable of responding to sound energy and especially the animals that rely on auditory signals to find mates, stake out territories, recognize young, detect and locate prey and evade predators. Further, these functions could be critically affected even if the animals appear to be completely adapted to the noise (i.e., they show no behavioral response such as startle or avoidance). Ultimately it does not matter to the animal whether these vital processes are affected through signal-masking, hearing loss, or effects on the neuro-endocrine system. Even though only those animals capable of responding to sound could be directly affected by noise, competition for food and space in an ecological niche appropriate to an animal's needs, results in complex interrelationships among all the animals in an ecosystem. Consequently, even animals that are not responsive to or do not rely on sound signals for important functions could be indirectly affected when noise affects animals at some other point in the ecosystem. The 'balance of nature' can be disrupted by disturbing this balance at even one point.

Furthermore, the EPA anticipates that the consequences of a loss of hearing ability could include a drastic change in the prey-predator situation. It states:

> The animal that depends on its ears to locate prey could starve if auditory acuity decreased, and the animal that depends on hearing to detect and avoid its predators could be killed. Reception of auditory mating signals could be diminished and affects reproduction. (Masking of these signals by noise in an area could also produce the same effect). Detection of cries of the young by the

mother could be hindered, leading to increased rates of infant mortality or decreased survival rates.

A noise study from Yellowstone involving four-stroke machines, which are much quieter than two-stroke snowmobiles, found that under a "best case scenario" (upwind, no temperature inversion, soft snow) snowmobiles were audible at distances of up to a half mile (NPS, 2000). When there was a temperature inversion or firm snow, or for those downwind of a snowmobile, the machines could be heard more than two miles away (NPS, 2000). At Yellowstone's Shoshone Geyser Basin, four-stroke snowmobiles were audible from 8 miles away (Burson, 2008). Other reports document snowmobile audibility up to 20 miles away (NPCA, 2000). The typical practice of snowmobilers to ride in groups (Snook, 1997) further amplifies noise levels.

Aftermarket modifications to snowmobiles continue to defeat reductions in noise. This practice is popular and is in part driven by market forces. As explained in an article in "Snowmobile Online" by Jerry Mathews, of Starting Line Products, "in the past, aftermarket systems have typically increased the noise level somewhat (in some cases immensely), as well as boosted the power (Mathews, 2002). This practice has been widely accepted and wasn't a large problem until just recently because these sleds were mostly used for racing, not pleasure riding. With more and more snowmobilers modifying their sleds and using them strictly for pleasure riding, it makes noise level enforcement difficult (Rivers and Menlove, 2006).

Wildlife Disturbance

Over Snow Vehicles can cause mortality, habitat loss, and harassment of wildlife (Boyle and Samson, 1985; Oliff *et. al.,* 1999). While most animals are well adapted to survival in winter conditions, the season creates added stress to wildlife due to harsher climate and limited foraging opportunities (Reinhart, 1999). Deep snow can increase the metabolic cost of winter movements in ungulates up to five times normal levels (Parker *et. al.,* 1984) at a time when ungulates are particularly stressed by forage scarcity and high metabolic demands. Disturbance and stress to wildlife from snowmobile activities during this highly vulnerable time is dire. Studies of observable wildlife responses to snowmobiles have documented elevated heart rates, elevated glucocoritcoid stress levels, increased flight distance, habitat fragmentation as well as community and population disturbance (Baker and Bithmann, 2005).

Snowmobiles have been implicated in the direct and indirect mortality of wildlife, including coyotes and gray wolves, by chasing them until they succumb to exhaustion, by intentionally striking the animals (Baldwin 1970, Malaher 1967, Wettersten 1971, Kopischke 1973, Heath 1974), by adversely impacting an animal's critical energy balance potentially resulting in increased mortality and/or decreased productivity, or by making the animal more vulnerable to predation as a result of displacement to unknown\marginal habitat or due to exhaustion.[13]

[13]Huff et al. (1972) in a survey of land and wildlife agency officials found that 62 % of game and fish enforcement personnel, 43 % of general game and fish personnel, 28 % of parks and recreation

In addition to the direct physiological stress of snowmobiles, evidence suggests that popular winter trails can fragment habitat and wildlife populations. Winter trails through surrounding wilderness areas or other core areas create more "edge effect" (the negative influence of the periphery of a habitat on the interior conditions of a habitat) and thereby marginalize the vitality of some species (Baker and Bithmann, 2005). In addition to the edge effect of groomed winter trails, off-trail riding or cutting trails through forested areas can further increase edge effects and fragmentation of habitat (Biodiversity Conservation Alliance, 2002).

In Yellowstone, Aune (1981) reported that heavy snowmobile traffic inhibits free movement of animals across roads to preferred grazing areas and temporarily displaces wildlife from areas immediately adjacent to the roads. Cole and Knight (1991) have also noted the displacement of elk along the roads during periods of fairly continuous travel by snowmobiles in the Madison and Firehole River Valleys of Yellowstone.

While winter climate, particularly snow, has an enormous impact on animal energy expenditures and stress, that impact is exacerbated by human-caused disturbance, including snowmobiling or other OSV use (See, Bury 1978 for a general description of the impacts of snowmobiles on wildlife). Indeed, researchers have suggested that additional human caused stress on wildlife in the winter is undesirable (Dorrance *et. al.,* 1975, Greer 1979, Moen 1976), since it may increase energy use and stress resulting in increased mortality, decreased productivity, and changes to behavioral adaptations (Moen 1976, Freddy 1977).

In many instances, snowmobiles induce animal flight, causing increased energy expenditures.[14] In Yellowstone National Park, for example, evasive maneuvers in response to snowmobiles have been documented in a number of species, including elk and mule deer. These maneuvers result in increased energy expenditures for the affected wildlife.[15] For example, Aune (1981) reported flight distances of 33.8 meters for elk and 28.6 meters for mule deer in response to snowmobiles in Yellowstone. The energy cost estimates calculated for these impacts were 4.9 to 36.0 kcal in elk and 2.0 to 14.7 kcal in mule deer per disturbance (*Parker et. al.,* 1984).[16] These energy expenditures are

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personnel, and 22 % of the forestry personnel felt that snowmobiles were either very harmful or moderately harmful through such activities as disruption of daily activity patterns, increased stress and energy expenditures, and chasing deer either intentionally or inadvertently by curious snowmobilers.

[14]It is important to note that snowmobile impacts on wildlife are not limited to a limited number of species, but rather affect a number of species, including avian species. Examples of snowmobile impacts which are associated with Yellowstone National Park are not limited to the Park but are indicative of broader impacts on public and private lands where snowmobiles are used.

[15]Indeed, of all recreational activities studied by Aune (1981), the most significant expenditures of energy created by recreationists occurred "during interaction along the groomed snowmobile trail and when photographers moved up for a closer shot."

[16]Similarly, Freddy *et. al.,* (1986) documented that mule deer moved 158 meters when fleeing from a single encounter with a snowmobile resulting in energy costs per encounter of 10-22 kcal or 0.4-0.8

roughly equivalent to the necessary additional consumption of 4.3 - 31.7 grams of dry forage matter by elk and 1.8 - 12.9 grams by mule deer each time a disturbance occurs. Severinghaus and Tullar (1978) theorize that for white-tailed deer, during a 20-week winter with snowmobile harassment each weekend, "food enough for 40 days of normal living would be wasted just escaping from snowmobiles."

While traveling on continuous packed surface greatly reduces the energy expenditure of wildlife it also increases their risk of getting hit (Richens and Lavigne*,* 1978). Furthermore the energy savings associated with the use of groomed trails may unnaturally increase animal survival and productivity causing a disruption to population dynamics and movement, distribution patterns, and habitat use patterns. While ungulates are known to use groomed trails (Aune 1981, Richens and Lavigne 1978, Meagher 1993, 1997) predators, such as red fox (Neumann and Merriam 1972) and wolves (International Wolf 1992, Paquet *et. al.,* 1997) have also been documented to use snowmobile trails[17] providing them access to area with potential prey which may have otherwise been unavailable due to snow depth. This allows coyotes to compete directly with lynx resulting in potential adverse impacts to the viability of this threatened species (Biodiversity Conservation Alliance, 2002). Consequently, snowmobiles trails may seriously disrupt the natural dynamics and ecology of ungulates, predator population dynamics and ecology, and predator-prey interactions.

While some animals may become accustomed to snowmobiles (Meagher 1993, Aune 1981), this does not mean that snowmobile impacts to the species are benign. The decrease in animal response to a particular stimulus over time may be in response to a progressive weakening of an animal's physical condition throughout the winter (Richens and Lavigne 1978, Severinghaus, 1947) and/or to preserve critical winter energy stores. Thus, although an animal's physical response to a particular stimulus may decrease in intensity with time, internal or physiological responses (e.g. stress levels, heart rate) may consistently rise as a result of such stimuli (Moen *et. al.,* 1982, MacArthur *et. al.,* 1979, Moen *et. al.,* 1978a, Thompson *et. al.,* 1968, Rongstad 1980). Such an increase may impair the survival and productivity of an animal.

As another consequence of disturbance, stress can, particularly if prolonged, cause substantial adverse impacts on individual animals. Stress may be caused by both physical and psychological factors, but, in either case stress results in physiological changes to the animal. OSV use, for example, may cause both physical and psychological stress to a wide range of animals as a result of noise impacts, pollution impacts, activity patterns, and direct and indirect harassment or disturbance. The effects of recreation-induced stress, including lower reproductive output (Geist, 1978), however, may not be evident immediately, but rather may appear days, weeks, months, or years after disturbances

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percent of the daily metabolizable energy. If disturbed by snowmobiles while grazing, the cost per encounter was 0.6-1 percent of their daily metabolizable energy. If disturbed while lying down, the energy expenditure per encounter increased from 2 to 10-25 kcal due to the flight response exhibited by the deer.

[17]Huff et al. (1972) found that mammals used snowmobiles trails more during times of deep snow or drifting and when traffic on the snowmobile trail was lowest.

(Gutzwiller, 1991). Moreover, recreation-induced stress may exacerbate the effects of disease and competition, and lead to higher mortality well after disturbances occur (Gutzwiller, 1991).

Ungulates

It has been widely documented that snowmobile activity disturbs wintering ungulates through physiological stress (Canfield *et. al.,* 1999) resulting in increased movements (Dorrance *et. al.,* 1975; Eckstein *et. al.,* 1979; Aune 1981, Freddy *et. al.,* 1986; Colescott and Gillingham 1998) and higher energy expenditures (Canfield *et. al.,* 1999). The physiological stress from snowmobile noise produces changes similar to those brought about by exposure to extreme heat, cold, or pain (EPA, 1971). During winter, when efficient energy expenditure is extremely important to an animal's survival, an additional stressor such as noise can throw off an animal's energy balance and is a serious threat to predator-prey relationships, mating, and reproduction, raising young, and staking out territories (EPA, 1971).

The flight response of ungulates to snowmobiles has been documented in a number of species (Aun, 1981; Hardy, 2001; Sevinhause and Tullar, 1978; and Freddy *et. al.,* 1986). A study of mule deer in north-central Colorado displayed responses to snowmobiles that ranged from benign to panic. Some of the less overt responses include increased metabolism, lowered body weight, reduced fetus size, and a withdrawal from suitable habitat (Freddy *et. al.,* 1986). A study conducted in Minnesota found that home range size, movement, and distance from radio-collared deer to the nearest trail increased with snowmobile activity (Dorrance *et. al.,* 1975).

Snowmobiles have been observed to displace elk from preferred habitat (Hardy, 2001; Freddy *et. al.,* 1986). Researchers also found that stress hormones in elk living in Yellowstone National Park fluctuated weekly, rising and falling in direct correlation with snowmobile activity (Creel, 2002). In one study, researchers found that large ungulates are disturbed by snowmobiles at distances over 1,250 feet (Blue Water Network, 2002). A recent study in Oregon found mechanized forms of recreation caused significantly larger reductions in feeding time and increases in travel time for elk than non-mechanized forms of recreation (Naylor, *et. al,* 2008)

Moose generally winter in willow and deciduous habitats adjacent to conifer stands at elevations where the snowpack is shallower and mobility is greater. Conflicts with winter recreation continue to increase moose habitat fragmentation and decrease moose habitat effectiveness (Colescott and Gillingham, 1998, WG&FD, 2003).

In regard to deer, Dorrance *et. al.,* (1975) suggest even low intensity snowmobile activity can result in displacement, increased movement, and an increase in home range sizes. Huff and Savage (1972) also reported that snowmobile activity resulted in altered home range sizes of deer and deer displacement into suboptimal habitat. In studies involving captive white-tailed deer Moen *et. al,* (1982) demonstrated an increase in the heart rate of the deer at least 250 percent over baseline levels as a result of snowmobile activity even

when the animals did not stand up or move away (See also, Freddy 1977). In response to these findings, Moen *et. al.,* (1982) concluded that: "Increases in heart rate and additional movements caused by encounters with snowmobiles must increase rather than decrease energy expenditures by deer. Such increases have the potential to affect the productivity of individuals and, ultimately, of the population."
Compaction of snow by snowmobiles may cause significant increases in energy costs by ungulates digging to access vegetation (Fancy and White 1985). Fancy and White (1985) reported that the amount of energy expended by caribou digging in snow to access forages was, on average, 118 J, 219 J, and 481 J per hoof stroke in uncrusted, hard crusted, and snowmobile compacted snow, respectively.

Indigenous Fish

The most diverse trout species in North America, native cutthroat trout are found along the Pacific Northwest coast, in the Cascade Range, the Great Basin, and throughout the Rocky Mountains. The cutthroat species has evolved through geographic isolation into at least ten subspecies, each native to a different major drainage basin (Duff, 1996). Two of the sub-species (the Yellowfin cutthroat trout and the Alvord cutthroat trout) are extinct. Three other subspecies (Lahontan cutthroat trout, Paiute cutthroat trout, and Greenback cutthroat) are listed on the U.S. Endangered Species List as threatened. Due to population declines several other subspecies, including Colorado River cutthroat trout, Westslope cutthroat trout, Bonneville cutthroat trout, and Yellowstone cutthroat trout have been considered for protection under the Endangered Species Act (Duff, 1996).

Similarly, bull trout, a threatened species protected under the Endangered Species Act, is in decline. Historically found in 60 percent of the Columbia River Basin, bull trout now occur in less than half of their historic range (USF&WS, 2010a). Bull trout depend on cold, clear water and are excellent indicators of water quality. In January 2010, U.S. Fish and Wildlife Service issued a proposed rule (50 CFR Part 17) to designate approximately 22,679 miles of streams and 533,426 acres of lakes and reservoirs in Idaho, Oregon, Washington, Montana and Nevada as critical habitat for the wide-ranging fish (USF&WS, 2010b).

According to the USF&WS news release accompanying the proposed rule "[c]ritical habitat for bull trout applies only to waterways. However, the proposal recognizes that associated flood plains, shorelines, riparian zones and upland habitat are important to critical habitat areas and that activities in these areas may affect bull trout critical habitat (USF&WS, 2010b)." Many of the high-elevation streams and lakes in the proposed critical habitat designation correspond closely with areas of high snowmobile use. These same waterways provide important habitat for salmon and other native fish species.

Trout can be directly impacted by snowmobile traffic across ice. Snowmobiles riding on top of ice can disturb trout concentrations in over-wintering areas. These disturbances place high energy demands on trout, and could be quite serious in oxygen depleted water (NPS, 2003). In addition to the direct mechanical impacts of snowmobiles on fisheries, the pollution associated with snowmobile emissions has been shown to degrade water quality and adversely impact fish (NPS, 2003; Ruzycki and Lutch, 1999).

A study on the impact of two-stroke emissions on trout, *Balk et. al.,* (1994) determined that hydrocarbons disrupt normal biological functions (e.g. DNA adduct levels, enzyme activity), including cellular and sub-cellular processes, and physiological functions (e.g. carbohydrate metabolism, immune system).[18] Serious disruption of trout reproduction and fry survival also seems likely.[19] (See also, Tjarnlund *et. al.,* 1995, 1996). Adams (1975) also found that the influence of lead and hydrocarbon on stamina, measured by ability to swim against a current, was significantly less in trout exposed to snowmobile exhaust than in control trout; the exposed trout made fewer tries to swim against the current, and swam for shorter lengths of time before resting.[20]

A study by Ruzycki and Lutch (1999) used captive brook trout to determine effects of snowmobile emissions on fish. The exhaust components taken up by the trout correlated with the levels present in the environment due to snowmobile use. The uptake of hydrocarbons occurs through the gills during respiration. Hydrocarbons initially rest on the surface of the water, but eventually sink, potentially impacting invertebrate and fish species, also accumulating in sediments. Hydrocarbons are incorporated into fatty tissues in a similar way to chlorinated hydrocarbon pesticides (Ruzycki and Lutch, 1999). Even at extremely low levels of hydrocarbon pollution trout may experience chromosome damage, retarded growth, disruption of normal biological functions, and death (Ruzycki and Lutch, 1999).

OSV use adds to other contributing factors including habitat modification, overfishing, whirling disease, zebra mussels, didymo algae, climate change, and the introduction of non-native fishes (Duff, 1996) in leading to declining native trout populations.

Subnivian Mammals

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[18]Additional evidence of such impacts comes from toxicologist James Oris and his colleagues at Miami University who conducted a study on the effects of hydrocarbon pollution from two-stroke marine engines, the exact same engine used by snowmobiles, on fish growth. The study, funded by the National Marine Manufacturers Association, found fish growth to be decreased by as much as 46% as a result of exposure to two-stroke water pollution. Although the study addressed concern about marine engines, snowmobiles are capable of creating similar levels of water pollution in streams, lakes and rivers due to frozen or trapped hydrocarbon pollution in snowpack and polycyclic aromatic hydrocarbon contamination described above.

[19]Juttner, et al. (1995) determined that the toxicity of water contaminated by a two-stroke engine was far higher than contamination caused by four-stroke engine or a catalyst equipped two-stroke engine. Two-stroke engines also emitted significantly more hydrocarbons and volatile organic compounds into the water than a four-stroke engine (Juttner, et al. 1995a). Experiments which replaced gasoline with 96 percent ethanol reduced the persistent toxicity but the toxicity of freshly contaminated water was still high. Modifying the lubricating oils used in the fuel blend, on the other hand, had little effect on toxicity.

[20]It is not clear in Adams (1975) whether the lead or hydrocarbons, or both, reduced the stamina measured in laboratory fish. Lead contamination is not as great a concern currently because of the existence and use of unleaded fuels. Unleaded fuel, however, contains trace amounts of lead which may accumulate in the environment causing adverse environmental impacts.

Winter temperatures, even with snow cover, are stressful to small mammals (Mezhzherin 1964, Schwartz *et. al.,* 1964, Fuller 1969, Fuller et al. 1969, Brown 1970, Beer 1961).[21] Many small mammal species depend on the space between the frozen ground and the snow to live. When snow compaction from snowmobiles occurs, the subnivean (below snow) space temperatures decrease, which can lead to increased metabolic rates in these small mammal species. If the subnivean air space is cooled by as little as 3 degrees Celsius, the metabolic demands of small mammals living in the space would increase by about 25 calories per hour (Neumann and Merriam, 1972).

Compaction can also create barriers that restrict movement of these small species that travel through tunnels in the subnivean space. As the subnivean trails are cut off these small mammals are forced up to the surface where they are venerable to predation (Canadian Wildlife Federation, 1998). Compaction can also restrict subnivian mammal movement to the point of causing asphyxiation, as oxygen flow is restricted and carbon dioxide builds up to deadly levels (Canadian Wildlife Federation, 1998).

Jarvinen and Schmid (1971) determined through controlled experiments that compaction due to snowmobile use reduced rodent and shrew use of subnivean habitats to near zero, and attributed this decline to direct mortality, not outmigration. In a study in Minnesota, Rongstad (1980) found that intensive snowmobiling on an old field eliminated the small mammal population in the layer between the ground and snow. Killing of subnivean species could well reduce the population of species preying upon them -- hawks, owls, foxes (Brander 1974). Population declines of small mammals undoubtedly impacts the species that prey open them creating ecosystem level disturbance.

White-Tailed Ptarmigan

White-tailed Ptarmigan (*Lagopus leucura*) is the smallest bird in the grouse family. White-tailed Ptarmigan are found in alpine habitats from south-central Alaska and northwest Canada south through the Cascade Mountains in Washington and the northern Rocky Mountains. Their distribution continues farther south on a more irregular and local basis through the southern Rocky Mountain ranges of Colorado and northern New Mexico (Braun *et. al.* 1993). The Rocky Mountain Region (R2) of the U.S. Forest Service Rocky lists white-tailed Ptarmigan as a sensitive species (USDA 2001).

White-tailed Ptarmigan reside in alpine areas at or above timberline. They do not migrate and remain in the alpine tundra above treeline during the winter (Braun *et. al.* 1993). Human disturbance including snowmobile activity can reduce the availability of winter forage for white-tailed ptarmigan (Anrews and Righter 1992). In order to protect White-tailed Ptarmigan Braun (1980) recommends the total exclusion of off-road vehicles from their habitat.

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[21]Snow cover is important to the survival of subnivean wildlife in north temperate and arctic latitudes because of the protection it affords from stresses of direct exposure to the severe winter climate and predation (Geiger 1965, Mail 1930, Formozov 1946, Pruitt 1957).

Threatened, Endangered, and Rare Species

In addition to adverse impacts to ungulates, OSVs have also been documented to directly, indirectly, and cumulatively impact federally protected species. For imperiled species like the grizzly bear, gray wolf, lynx, and wolverine OSV use can cause disturbance, adversely impact animal energetics, negatively impact prey/carrion availability, cause habitat abandonment, and can otherwise impact predator/prey interactions to the detriment of the species.[22]

Canada Lynx

In 2000 the Canada lynx (*Lynx canadensis)* was listed as a Threatened Species under the endangered Species Act for the lower 48 states. OSV trails that are created by winter recreation and forest management activities enable coyotes to access lynx habitat not normally accessible to them (Koehler and Aubry 1994, Buskirk, 2000, Brunnel, *et.al.,* 2006). This was evident in a study in Utah by Brunnel *et.al.,* (2006) that found the presence of snowmobile trails a good indicator of coyote activity in deep snow areas. Over 90 percent of coyote tracks observed in the Brunnel *et.al.,* (2006) study were less than 350 meters from a snowmobile trail. On Wyoming's Togwotee pass Burghardt (2009) also found snowmobiles are facilitating coyote access to lynx habitat. Burghardt (2009) reports 100 percent of all observed coyote tracks utilized snow compaction and on average coyotes used snow compacted trails for 34 percent of the track.

Coyotes aggressively compete with, or prey upon, a number of different vertebrate species, including Canada lynx, that are adapted and limited to deep snow (Buskirk *et. al.,* 2000). Koehler and Aubry (1994) determined that inter-specific competition during late winter, a time when lynx are already nutritionally stressed, may be especially detrimental to lynx.[23] Consequently, the presence of OSVs and compacted snow roads on public lands occupied by lynx are likely to adversely impact the survival and viability of such populations. In an effort to mediate competition with coyotes, Brunnel *et.al.* (2006) recommends restrictions are placed on snowmobiles in lynx conservation areas.

[22]This is not to suggest that OSV impacts to threatened and endangered species are limited to grizzly bears, wolves, and lynx. Indeed, OSVs may have considerable adverse impacts on other imperiled species, including fish and amphibians as a result of pollution, birds due to harassment resulting in nest abandonment, and small mammals because of disturbance, displacement, direct mortality, and snow compaction resulting from snowmobile use and/or trail grooming.

[23]Canada lynx may be displaced or eliminated when competitors (e.g., bobcat, coyote) expand into its range (deVos and Matel 1952, Parker *et. al.,* 1983, Quinn and Parker 1987). The Canada lynx is at a competitive disadvantage against those other species because it is a specialized predator, whereas bobcat and coyotes are generalists that are able to feed on a wide variety of prey. Historically, bobcat and coyotes have not been able to compete with lynx in areas that receive deep snow, where lynx are much more highly adapted (McCord and Cardoza 1982, Parker *et. al.,* 1983, Quinn and Parker 1987). When snowmobile trails are available, coyotes and bobcats, can exert a greater impact on snowshoe hare populations -- the predominant prey of the lynx -- than if snowmobile trails were not available (Murray and Boutin 1991).

Gray Wolf

By the 1930's, the Rocky Mountain gray wolf (*Canis lupis*) was completely exterminated from the continuous 48 States. Listed as an endangered species in 1973, gray wolves have naturally reestablished themselves in Northern Montana and were re-introduced to Yellowstone National Park and Central Idaho in 1995. Gray wolf populations have expanded and the northern Rockies gray wolf has been removed from the Endangered Species list though a number of protections remain in place.

Since wolf survival and production is affected by winter food intake, the availability and accessibility of prey in winter affects wolf numbers (Nelson and Mech 1986). OSV trails, whether created by snowmobiles or grooming equipment, may adversely alter predator-prey dynamics, habitat use, predator and ungulate movement and distribution patterns, thereby affecting the availability and accessibility[24] of prey to predators, and also affecting community structure and composition (Paquet *et. al.,* 1997). These trails can also facilitate predator expansion into areas where they are more likely to have negative interactions with humans, livestock and pets.

For example, Paquet *et. al.,* (1997) compared wolf use of modified trails (i.e. plowed roads, snowmobile trails, and ski trails) to natural trails (i.e. trails made by wildlife) in several national and provincial parks in Canada. Their data reveals that "wolves ... clearly preferred established travel routes (modified trails) composed of compacted snow, snow free roads, and open areas of shallow snow." Wolves also used human-modified trails in the winter to cross or traverse upper elevation areas where normally such movements would be precluded due to excessive snow depth.

Similarly, wolves have difficulty moving in snow deeper than 50 cm (Pullianen, 1982). Consequently, in Parks like Yellowstone where wolves are present and snow depth in some areas may exceed 50 cm, wolf movements and use of these areas may be precluded by snow depth. If modified or groomed trails traverse these areas, however, they provide energy and movement efficient travel corridors for wolves to access habitats that otherwise would not have been available. Such an effect, as Paquet *et. al.,* (1997) reports, could have unanticipated consequences, including: the modification of wolf predation by facilitating movements between patches of prey; changing the relationship between habitat use, prey distribution, and topography; altering dispersal patterns; and facilitating access to winter ungulate ranges or agricultural areas which would normally be unavailable.

Snowmobiling has been shown to cause stress in wolves. In Minnesota a relatively new research technique, fecal analysis, was used to compare the hormone levels of wolves in Isle Royale, where there are no snowmobiles, to those of wolves in Voyageurs, where

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[24] Since prey are more easily killed by predators in deeper snow, ungulate use of snowmobile trails to access and use alternative wintering sites at lower elevation and with less snow, may adversely impact the ability and efficiency of wolves to kill wild prey to meet their nutritional requirements. In turn, wolves may alter their movements to correspond to changes in ungulate movements, and/or may pursue alternative prey, including domestic livestock.

snowmobiling is pervasive. The Voyageurs wolves consistently exhibited higher levels of stress hormones (Creel, 2002). In addition, the scientists noted another direct relationship between snowmobiles and stress. When snowmobile use declined 37 percent in Voyageurs between the winters of 1999 and 2000, fecal stress hormone levels also dropped in the park's wolf population by 37 percent (Creel, 2002).

Grizzly Bear

Loss of habitat and high mortality rates resulting from conflicts with humans led to the grizzly bear *(Ursus arctos)* being listed as a threatened species in 1975. In Yellowstone the population of grizzly bears *has* increased from a low of approximately 200 bears in the late 1960s to over 600 today. In 2007, grizzly bears were determined to have recovered and therefore removed from the endangered species list. In 2009 this decision was reversed and grizzly bears were re-listed as a threatened species.

Though only a few National Forests are occupied by grizzly bears, the adverse impacts of OSV use, namely snowmobile use and trail grooming, on grizzly bears in Yellowstone demonstrates how OSV can cause indirect impacts that may normally be overlooked. These impacts may, however, be applicable to other National Forests including the Targhee, Bridger-Teton, Gallatin, Flathead, Kootenai, Idaho Panhandle, Custer, Lewis and Clark, Bighorn and the Shoshone since grizzly bears are present, snowmobile use is permitted, and the grooming of hundreds of miles of snowmobile trails is allowed. In May 2008 U.S. District Judge Donald Malloy ruled that late-season snowmobiling on the Flathead National Forest negatively impacts grizzly bear habitat when bears are emerging from their dens and instructed the Forest to curtail spring OSV use (Woody, 2009). This may also be relevant to other National Forests that provide potential habitat for the future reintroduction of grizzlies.

While most direct snowmobile impacts on grizzlies are limited due to grizzly denning during the peak period of snowmobile use,[25] scientific studies have made it clear that indirect impacts are adversely affecting grizzlies. Indirect impacts result from the altered distribution and movement patterns of large ungulates, particularly bison and elk, caused by snowmobile trail use (Knight *et. al.*, 1984; Mattson, 1997). This leads to a subsequent decrease in the availability and accessibility of critical grizzly food sources, namely carrion.[26]

[25] Knight (1976) documented at least one incident where snowmobiles may have disrupted a denning grizzly bear causing the bear to relocate to a second den site. Impacts to denning bears have likely increased in recent years due to improvements in snowmobile technology which has created machines which can travel further, faster, and which are more powerful than snowmobiles in the past. As a result, areas which previously were inaccessible to snowmobiles, including areas used by grizzly bears for denning, have now become accessible.

[26] Air pollution impacts to Park vegetation may be another indirect effect of snowmobile use on grizzlies. These impacts may affect all components of the food chain, including grizzly bears and other threatened and endangered species, as a result of bioaccumulation of toxins in Park herbivores (See Shaver et al. 1988).

For grizzlies, winter-killed carrion is "an important source of protein" during the crucial bear feeding time in the late winter and early spring after den emergence (NPS 1983; Knight *et. al.,* 1984). As stated by Mattson (1997):

> Spring grizzly bear habitat productivity in Yellowstone is a function primarily of ungulate availability (Knight et al.1984). Spring productivity in turn apparently plays a major role in determining productivity, condition, and ultimately survivorship of adult female grizzlies in the Yellowstone areas. Knight and Eberhardt (1985) have identified female survivorship as key to the future viability of the Yellowstone grizzly bear population. Thus, over-winter ungulate mortality and condition are identified as an important regulatory factor, and an area where management might potentially benefit the Yellowstone grizzly bear population.

The availability and use of carrion by grizzly bears is of critical importance for species survival and viability. Considering the decline or variability in other important grizzly food items, including the army cutworm moth, cutthroat trout, and whitebark pine nuts, the relative importance of carrion as a spring food source for grizzly bears has increased (Gunther and Haroldson, 1997). The availability and accessibility of such carrion, however, is adversely affected by snowmobiling activities.

Whitebark pine is an important food source for grizzlies. As discussed above, snowmobiles can harm trees, including whitebark (which often grow in high elevation areas at or above tree line frequented by snowmobilers). Given the recent petition to list the Whitebark Pine as an endangered species (NRDC, 2008) protection of this grizzly bear habitat component from damage such as that caused by OSV's is imperative.

Grizzlies avoid roads and developments even when carrion is available in those corridors (NPS, 1990). This is of critical importance to bear survival and viability given that most spring carrion occurs on ungulate winter ranges that are located at lower elevations, near roads and developments (Houston, 1982). The prevalence of carrion near roads is also undeniably influenced by ungulate use of groomed snowmobile roads as travel corridors. The groomed roads, therefore, not only alter the natural distribution and movement patterns of bison and other ungulates, but also affect grizzly bear access to carrion, potentially resulting in reduced bear productivity and survival.[27]

Wolverine

While several petitions to protect wolverines (*Gulo gulo*) under the federal Endangered Species Act have been filed in recent years, the U.S. Fish and Wildlife Service has so far decided against all listing attempts. However, wolverines are designated as sensitive on many forests and a species of special concern in several States.

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[27]Grizzly avoidance of ungulate carcasses near roads may also cause artificial alterations to grizzly movements, distribution, and predator/prey interactions in conflict with NPS grizzly bear management policies, possibly leading to greater human grizzly conflict.

Wolverines occur naturally in low densities and are believed to be territorial (WCS, 2007). Wolverine parturition primarily occurs mid-winter during the month of February (WCS, 2007). Six of the seven natal dens located in the Greater Yellowstone Ecosystem by the Wildlife Conservation Society (2007) were in areas without motorized use, i.e., designated wilderness, areas inaccessible by vehicle, or national park. Other wolverine biologists have suggested refuge from human activity is important for wolverine reproduction (Banci, 1994; Magoun and Copland, 1996). Female wolverines appear to be quite sensitive to human disturbance in the vicinity of natal and maternal dens, and may abandon dens and move their kits a considerable distance if they detect human presence in the area (Copeland 1996, Magoun and Copeland 1998).

In a study of wolverines in Idaho, Copeland (1996) concluded that "technological advances in over-snow vehicles and increased interest in winter recreation has likely displaced wolverines from potential denning habitat and will continue to threaten what may be a limited resource."

References

Adams, E.S., 1975. Effects of Pb and hydrocarbons from snowmobile exhaust on brook trout (*Salvenlinus foninalis*). Trans. Amer. Fish Soc. 104:363.

Andrews, R., and Righter, R., 1992). *Colorado Birds: a reference to their distribution and habitat*. Denver Museum of Natural History, Denver, CO.

Ashmore, M.R., and Ainsworth, N., 1995. The effects of ozone and cutting on the species composition of artificial grassland communities. Functional Ecology 9:708-712.

Atkins, D.P., Trueman, I.G., Clarke, C.B., and Bradshaw, A.D., 1982. The evolution of lead tolerance by *Festuca rubra* on a motorway verge. Environmental Pollution (series A). 27:233-241.

Aune, K.E., 1981. Impacts of Winter Recreationists on Wildlife in a Portion of Yellowstone National Park, Wyoming. Master's thesis. Montana State University.

Baker, E. and Bithmann, E., 2005. Snowmobiling in the Adirondack Park: Environmental and Social Impacts. St. Lawrence University, Department of Biology.

Baker, J.P., and Christensen, S.W. 1991. Effects of Acidification on Biological Communities in Aquatic Systems. *In* D.F. Charles, ed., Acidic Deposition and Aquatic Ecosystems -- Regional Case Studies. Springer Verlag. New York, New York, USA.

Baldwin, M.F. 1970. The off-road vehicle and environmental quality: A report on the social and environmental effects of off-road vehicles, particularly snowmobiles, with suggested policies for their control. Conservation Foundation. Washington, D.C., USA.

Baldwin, M. F. and Stoddard Jr., D., 1973. The off-road vehicle and environmental quality. Pages 8-27. Second Edition. The Conservation Foundation, Washington, D.C., USA.

Balk, L., Ericson, G., Lindesjoo, E., Petterson, I. Tjarnlund, U. and Akerman, G., 1994. Effects of Exhaust From Two-Stroke Outboard Engines on Fish. Institute of Applied Environmental Research, Laboratory for Aquatic Ecotoxicology, Stockholm University.

Banci, V. 1994. Wolverine. Pages 99-127 in L. F. Ruggiero et al. (eds.) The Scientific Basis for Conserving Forest Carnivores—American Marten, Fisher, Lynx, and Wolverine in the Western United States. General Technical Report RM-254. Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Bazzaz, F.A., and Garbutt, K., 1988. The response of annuals in competitive neighbourhoods: effects of elevated carbon dioxide. Ecology 69:937-946.

Becker, K., Saurer, M. Egger, A., and Fuhrer, J., 1989. Sensitivity of white clover to ambient ozone in Switzerland. New Phytologist 112: 235-243.

Beebee, T.J.C. and Griffin, J.R., 1977. A preliminary investigation into nattarjack toad (*Bufo calamita*) breeding site characteristics. Great Britain Journal of Zoology 181:341-350.

Beer, J.R., 1961. Winter home ranges of the red-backed mouse and the white-footed mouse. Journal of Mammalogy 42:174-180.

Berry, K.H. 1980. The effects of four-wheel vehicles on biological resources. R.N.L. Andrews and P. Nowak, editors. Off-road vehicle use: A management challenge. U.S. Department of Agriculture, Office of Environmental Quality, Washington, D.C.

Biodiversity Conservation Alliance, 2002. Keep the Medicine Bow *WILD*: An Ecosystem Management Alternative for the Medicine Bow National Forest Plan Revision. Laramie, WY.

Bjornstig, U., Ostrom, M., and Eriksson, A., 1994. Would a helmet law for snowmobile riders reduce head injuries? Arctic Med. Res. 53:196-199.

Blanchard, C., Michaels, H., Bradman, A., and Harte, J., 1987. Episodic acidification of a low-alkalinity pond in Colorado. ERG publ. 88-1. Energy and Resources Group, University of California, Berkeley, CA 94720.

Bluewater Network. 1999. Petition to prohibit snowmobiling and road grooming in National Parks. Submitted to the National Park Service.

Bluewater Network. 2002. Snowmobile Position Paper. Available: www.bluewaternetwork.org/reports/rep_pl_snow_snowposition.pdf

Boyle, S. A. and Samson F,B., 1985. Effects of Non-consumptive Recreation on Wildlife: A Review. Wildlife Society Bulletin 13: 110-116.

Brander, R.B., 1974. Ecological impacts of off-road recreation vehicles. General Technical Report NC-9. Outdoor recreation research: Applying the results. U.S. Department of Agriculture, U.S. Forest Service.

Brattstrom, B.H., and Bondello, M.C., 1983. Effects of off-road vehicle noise on desert Vertebrates *in* R.H. Webb and H.G Wilshire, editors. Environmental effects of off- road vehicles: Impacts and management in arid regions. Springer-Verlag. New, York, New York, USA.

Braun, C.E., 1980. Alpine bird communities of western North America: implications for management and research. Pages 280-291 **in** Workshop proceedings: management of western forests and grasslands for nongame birds. U.S. Forest Service General Technical Report INT-86.

Braun, C. E., Martin, K., and Robb L.A., 1993. White-tailed Ptarmigan (*Lagopus leucurus*). *In* The Birds of North America, No. 68 (A. Poole and F. Gill, Eds.). Philadelphia, PA: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Brown, E.B., 1970. Some aspects of the ecology of the small, winter-active mammals of a field and adjacent woods in Itasca Park, Minnesota. Dissertation. University of Minnesota, Minneapolis, Minnesota, USA.

Brunnel, K.D., Fliners, J.T., and Wolfe M.L., 2006. Potential Impacts of Coyotes and Snowmobiles on Lynx Conservation in the Intermountain West. Wildlife Society Bulletin, 34(3): 828-838.

Burghardt, J. 2009. Personal correspondence.

Burson, S., 2008. Natural Soundscape Monitoring in Yellowstone National Park December 2007-March 2008. Yellowstone Center for Resources. USGS.

Bury, R.L. 1978. Impacts of Snowmobiles on Wildlife. Transcript. 43rd North American Wildlife and Natural Resource Conference. WMI.

Buskirk, S.W., Romme, W.H., Smith, F.W., and Knight, R.L., 2000. An overview of forest fragmentation in the southern Rocky Mountains. Pp. 3-14 *in* Forest fragmentation in the southern Rocky Mountains, Boulder: University Press of Colorado.

Canadian Wildlife Federation, 1998. Below Zero Activities: Snowmobile Savvy. Wild Education: Wild Programs www.wildeducation.org

Canfield, J.E., Lyon, J., Hillis, J.M. and Thompson, M.J., 1999. Effects of recreation on Rocky Mountain wildlife: A review for Montana. Montana Chapter of the Wildlife Society, pp 307.

Center for Disease Control. 1995. Injuries associated with the use of snowmobiles- New Hampshire, 1989-1992. Morb. Mortal. Wkly. Rep. 44: 1-3.

Center for Disease Control. 1997. Injuries and deaths associated with use of snowmobiles- Maine, 1991-1996. Morb. Mortal. Wkly. Rep. 46:1-4.

Charette, J.Y., Hammerli, J., and Papineau, M., 1990. Tech. Sci. Methods. 87(2):85-90.

Cole, D.N., and Knight, R.L., 1991. Wildlife preservation and recreational use: Conflicting goals of wildland management. Trans. N. American Wildlife and Natural Resource Conference 56:233-237.

Colescott, J.H., and M.P. Gillingham. 1998. Reaction of Moose (*Alces alces*) to Snowmobile Traffic in the Greys River Valley, Wyoming. Alces 34(2):329-338.

Cooke, A.S., and J.D.F. Frazier, J,D.F., 1976. Characteristics of newt breeding sites. Journal of

Zoology of London 178:223-236.

Copeland, J.P., 1996. Biology of the wolverine in central Idaho. Thesis. University of Idaho, Moscow, Idaho, USA.

Corn, P.S., and Vertucci, F.A. 1992. Descriptive risk assessment of the effects of acidic deposition on Rocky Mountain amphibians. Journal of Herpetology. 26:361-369.

Creel, S., Fox, J. E., Hardy, A., Sands, J., Garrot, B., and Peterson, R.O. 2002. Snowmobile Activity and Glucocorticoid Stress Responses in Wolves and Elk. Conservation Biology 16 (3): 809-814.

DeVos, A., and Matel., S.E. 1952. The status of lynx in Canada, 1929-1952. Journal of Forestry 50:742-745.

Dorrance, M.J., Savage, P.J., and Huff, D.E.,1975. Effects Of Snowmobiles On White-Tailed Deer. Journal of Wildlife Management 39 (3): 563-569.

Duff, D., 1996. Conservation Assessment For Inland Cutthroat Trout. Distribution, Status and Habitat Management Implications. U.S. Department of Agriculture, Forest Service, Intermountain Region, Ogden, Utah.

Eckstein, R.G., O'Brien, T.F., Rongstad, O.R. and Bollinger. J.G., 1979. Snowmobile effects on movements of white-tailed deer: A case study. Environmental Conservation. 6:45-51.

Environmental Protection Agency, 1971. Effects of Noise on Wildlife and Other Animals. Prepared by Memphis State University

Environmental Protection Agency, 1993. Motor Vehicle-Related Air Toxics Study.

Environmental Protection Agency, 1994. Measuring air quality: The pollutant standards index. Office of Air Quality Planning & Standards. EPA 451/K-94-001.

Environmental Protection Agency,2002. Environmental Impacts of Newly Regulated Non-road Engines: Frequently Asked Questions. Office of Transportation and Air Quality.

Eriksson, A., and U. Bjornstig. Fatal snowmobile accidents in northern Sweden. J. Trauma. 22: 977-982.

Falkengren-Grerup, U. 1986. Soil acidification and vegetation changes in deciduous forest in southern Sweden. Oecologia. 70:339-347.

Fancy, S.G., and White, R.G., 1985. Energy expenditures by caribou while cratering in snow. Journal of Wildlife Management 49(4):987-993.

Ferris, R., and Taylor, G., 1995. Contrasting effects of elevated CO_2 and water deficit on two native herbs. New Physiologist 131:491-501.

Findlay, D.L., and Kasian, S.E.M., 1986. Phytoplankton community responses to acidification of Lake 223, Experimental Lakes Area, northwestern Ontario. Water Air Soil Pollution. 30:719-726.

Freda, J., and W.A. Dunson. 1985. The influence of external cation concentration on the hatching of amphibian embryos in water of low pH. Canadian Journal of Zoology 63:2649-2656.

Freddy, D.J. 1977. Snowmobile harassment of mule deer on cold winter ranges. Job Progress Report, Deer-Elk Investigations. Colorado Division of Wildlife. Project No. W-38-R-32.

Freddy, D.J., Bronaugh, W.M., and Fowler, M.C., 1986. Responses Of Mule Deer To Disturbance By Persons Afoot And Snowmobiles. Wildlife Society Bulletin 14: 63-68.

Fuller, W.A., 1969. Changes in numbers of three species of small rodents near Great Slave Lake, N.W.T., Canada, 1964-1967, and their significant for general population theory. Ann. Zool. Fennici. 6:113-144.

Fuller, W.A., Stebbings, L.L., and Dyke, G.R., 1969. Overwintering of small mammals near Great Slave Lake, northern Canada. Arctic 22:34-55.

Fussell-Snook, L.M., 1997. Exposure of snowmobile riders to carbon monoxide: Emissions pose potential risk. Park Science 17(1):1,8-10.

Gabert, T., and Stueland, D.T., 1993. Recreational injuries and deaths in northern Wisconsin: analysis of injuries and fatalities from snowmobiles over three years. WI Med. Jnl. 92: 671-675.

Geist, V., 1978. Behavior. Pages 283-296 *in* J.L. Schmidt and D.L. Gilbert, editors, *Big game of North America: Ecology and Management.* Stackpole Books. Harrisburg, Pennsylvania, USA.

Greer, T., 1979. Environmental impact of snowmobiles: A review of the literature. Masters Project. University of Oregon, Eugene, Oregon, USA.

Gunderson, C.A., and Taylor, G.E., 1988. Kinetics of inhibition on foliar gas exchange by exogenous ethylene: an ultrasensitive response. New Phytologist 110:517-524.

Gunther, K., and Haroldson, M., 1997. Comments on the importance of bison to grizzly bears in the Yellowstone ecosystem. Unpublished Report. Yellowstone National Park.

Gutzwiller, K.J., 1991. Assessing recreational impacts on wildlife: The value and design of experiments. Transactions of the 56th North American Wildlife and Natural Resources Conference. 248-255.

Hagen, A., and Langeland, A., 1973. Polluted snow in southern Norway and the effect of the meltwater on freshwater and aquatic organisms. Environmental Pollution 5:45-57.

Hardy, A.R., 2001. Bison and Elk Responses to Winter Recreation in Yellowstone National Park. M.S. Thesis, Montana State University.

Harper, J.L., Williams, J.T., and Sager, G.R., 1965. The Behavior of Seeds in Soil I. The Heterogeneity of Soil Surfaces and its Role in Determining the Establishment of Plants from Seed. J. Ecology. 53:273-286.

Harte, J., and Hoffman E., 1989. Possible Effects of Acidic Deposition on a Rocky Mountain Population of the Tiger Salamander (*Abystoma tigrinum*). Conservation Biology. 3:149-158.

Heath, R. 1974., A look at snowmobile damage. ORV Monitor. Environmental Defense Fund, Berkeley, California, USA.

Houston, D.B., 1982. The northern Yellowstone elk: ecology and management. Macmillan Publ. Co., Inc., New York, NY. 474 pp.

Huff, D.E., and P.J. Savage., 1972. A correlation of deer movements with snowmobile activity in Minnesota during winter. Proceedings of the Midwest Fish and Wildlife Conference. 34: 42-49.

Ingersoll, G.P., Turk, J.T., McClure, S. C., Lawlor, Clow, D.W., and Mast, M.A., 1997. Snowpack chemistry as an indicator of pollutant emission levels from motorized winter vehicles in Yellowstone National Park.

Ingersol, G.P., 1998. Effects of Snowmobile Use on Snowpack Chemistry in Yellowstone National Park.

International Wolf. 1992. Snowmobiles versus wolves. International Wolf, Spring 1992.

Iqbal, M.Z., 1988. Accumulation of sulfur in foliage of roadside plantation and soil in Karachi city (Pakistan). Tropical Ecology 298:1-5.

Iqbal, M.Z. 1990. Influence of low-levels of sulfur dioxide and nitrogen dioxide on Holcus lanatus (L). Opulations at different sulfate and nitrate nutrients. Ekologia-CSSR. 9: 87-92.

James, E.C., Lenz, J.O., Swenson, W.M., Clooney, A.M., and Gomez, Y.L., 1991. Snowmobile trauma: An eleven year experience. Am. Surg. 57: 349-353.

Janssen, R. 1978. Effects of noise on wildlife -- noise and animals: Perspective of government and public policy. Office of Noise Abatement and Control, U.S. Environmental Protection Agency, Washington, DC.

Janssen, S. and Schettler, T., 2003. Health Implications of Snowmobile Use in Yellowstone National Park.

Jarvinen, J.A., and W. D. Schmid. 1971. Snowmobile Use and Winter Mortality of Small Mammals. Pp. 131-141 in M. Chubb (ed.), Proc. of the Snowmobile and Off-Road Vehicle Research Symposium. Michigan State Univ. Tech. Rep. 8, 196 pp.

Jarvinen, J.A., and Schmid, W.D., 1971. Snowmobile use and winter mortality of small mammals. *In* J. Chubb, editor. Proceedings of the snowmobile and off the road vehicle research symposium. College of Agriculture and Natural Resources, Department of Park and Recreation Resources, Recreation Resources and Planning Unit. Tech. Rep. 8. Michigan State University, East Lansing, Michigan, USA.

Jeske, C.W. 1985. Time and energy budgets of wintering ring-necked ducks Ayatha collaris (L.) in north-central Florida. Thesis. University of Florida, Gainesville, FL, USA.

Juttner, F., Backhaus, D., Matthias, W., Essers, U., Greiner, R., and Mah, B., 1995. Emissions of two and four-stroke outboard engines -- II. Impact on water quality. Wat. Res. 29(8):1983-1987.

Juttner, F., Backhaus, D., Matthias, W., Essers, U., Greiner, R., and Mah, B., 1995a. Emissions of two and four stroke outboard engines I. Quantification of Gases and VOC. Wat. Res. 29(8):1976-1982.

Keddy, P.A., Spavold, A.J., and Keddy, C.J., 1979. Snowmobile Impact on Old Field and March Vegetation in Nova Scotia, Canada: An Experimental Study. Environmental Management. 3(5):409-415.

Kiesecker, J. 1991. Acidification and its effects on amphibians breeding in temporary ponds in Colorado. Thesis. University of Northern Colorado.

Knight, R.R., Mattson, D.J. and Blanchard B.M., 1984. Movements and Habitat Use of the Yellowstone Grizzly Bear. U.S.D.I. natl. Park Service., Interagency Grizzly Bear Study Team .

Knight, R.R., and Eberhardt, L.L., 1985. Population dynamics of Yellowstone grizzly bears. Ecology 66:323-334.

Koehler, G.M., and Aubry, K.B., 1994. Lynx. Pages 74-98 in L.F. Ruggiero, K.B. Aubrey, S.W. Buskirk, L.J. Lyon, and W.J. Zielinski, editors. The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx and Wolverine in the Western United States.

Kopischke, E.B., 1972. Effects of snowmobile activity on the distribution of white-tailed deer in South-Central Minnesota. Minnesota Department of Natural Resources, Game Research Project Quarterly Report. 32(3):139-142.

Landen, M.G., Middaugh, J., and Dannenberg, A., 1999. Injuries associate with snowmobiles, Alaska, 1993-1994. Pub. Health Rep. V. 114, No. 1, pp. 48-52.

Luckenbach, R.A., and Bury, R.B., 1983. Effects of off-road vehicles on the biota of Algodones Dunes, Imperial County, California. J. Appl. Ecology 20:265-286.

MacArthur, R.A., Geist, V., and Johnston, R.H., 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. Journal of Wildlife Manage. 46:351-358.

Magoun, A. J. and Copeland, J. P., 1998. Characteristics of wolverine reproductive den sites. J. Wildl. Manage. 62(4):1313-1320.

Malaher, G.W. 1967. Improper use of snow vehicles for hunting. Proceedings of the Thirty-Second North American Wildlife Conference. Pgs. 429-433.

Mathews, J., 2002. “What is Noise? Is snowmobiling being silenced?” Starting Line Products. Available: www.off-road.com/snowmobile/info/sound/whatisnoise.htm.

Mattson, D.J. Use of Ungulates by Yellowstone Grizzly Bears *Ursus arctos*. Biological Conservation. 81:161-177. 1997.

McCord, C.M., and Cardoza, J.E., 1982. Bobcat and Lynx. Pages 728-766 *in* J.A. Chapman and G.A. Feldhamer, editors. Wild mammals in North America: biology, management, and economics. John Hopkins University Press, Baltimore.

McManus, C., Coupal, R., and Taylor, D., 2001. Results From 2000-2001 Wyoming Snowmobile Survey: Executive Summery. Department of Agricultural and Applied Economics University of

Wyoming. Available:
http://wyotrails.state.wy.us/Research/WYOMINGSNOWMOBILEEXECUTIVE.pdf

Meagher, M., 1993. Winter recreation-induced changes in bison numbers and distribution in Yellowstone National Park. Unpublished Report. Yellowstone National Park.

Meagher, M., Cain, S., Toman, T., Kropp, J., and Bosman, D., 1997. Bison in the Greater Yellowstone Area: status, distribution, and management. Proceedings of the National Brucellosis Symposium. Jackson, WY. September 1994.

Mezhzherin, W.A., 1964. Dehnel's phenomenon and its possible explanation. Acta Theriologica 8:95-114

Moen, A.N., 1976. Energy conservation by white-tailed deer in the winter. Ecology 57:192-198.

Moen, A.N., 1978. Seasonal changes in heart rates, activity, metabolism, and forage intake of white-tailed deer. Journal of Wildlife Management. 42(4):715-738.

Moen, A.N., Whittemore, S., and Buxton, B., 1982. Effects of disturbance by snowmobiles on heart rate of captive white-tailed deer. New York Fish and Game Journal 29(2):176.

Mooney, H.A., Kuppers, M., Koch, G.W., Gorman, J., and Chu, C.C., 1988. Compensating effects to growth of carbon partitioning changes in response to SO2- induced photosynthetic reduction in radish. Oecologica 75: 502-506.

Murray, D.L., and Boutin, S., 1991. The influence of snow on lynx and coyote movements: does morphology effect behavior? Oecologia 88:463-469.

National Parks Conservation Association (NPCA), 2000, Yellowstone Sound Survey. Available: http://www.npca.org/media_center/reports/yellowstone.html

Naylor, L,M., Wisdom, M.J., and Anthony, R.G., 2008. Behavioral Responses of North American Elk to Recreational Activity. Journal of Wildlife Management, 73(3):328–338

Nelson, M.E., and Mech, L.D., 1986. Relationship between snow depth and gray wolf predation on white-tailed deer. Journal of Wildlife Management, 50(3):471-474.

Neumann, P. W., and Merriam, H.G., 1972. Ecological effects of snowmobiles. The Canadian Field-Naturalist, 86:207-212.

Oliff, T.K., Legg, K., and Kaeding, B. 1999. "Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment." Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park.

Paquet, P.C., Poll, D., and Callaghan, C. 1997. The influence of snow cover on movements of gray wolves.

Parker, K.L., Robbins, C.T. and Hanley, T.A., 1984. Energy expenditures for locomotion by mule deer and elk. Journal of Wildlife Management. 48(2):474-488.

Pierce, B.A., and Wooten, D.K., 1992. Genetic Variation in tolerance of amphibians to low pH. J.

Herpetol. 26: 422-429.

Pirnie, M., 1998. Taste and odor properties of MTBE and implications for setting a secondary maximum contaminant level. Prepared for the Oxygenated Fuels Assoc., June 26, 1998.

Pulliainen, E., 1982. Behavior and structure of an expanding wolf population in Karelia, northern Europe. In: Wolves of the world**.** Harrington F. H. and Paquet P. C., eds. Noyes Publications, New Jersey: 134-145.

Quinn, N.W.S., and Parker, G., 1987. Lynx. *In* Novak, M., J.A. Baker, M.E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources.

Rawlins, C.L. 1993. *Sky's Witness: A Year in the Wind River Range*. Henry Holt and Company, New York.

Reich, P.R., and Amundson, R.G., 1985. Ambient levels of ozone reduce net photosynthesis in tree and crop species. Science 230: 566-570.

Reinhart, D., 1999. Effects of Winter Recreation on Habituated Wildlife. National Park Service: Effects of Winter Recreation on Wildlife: 151-153.

Renninson, D.C. and Wallace, A., 1976. The extent of acoustic influence on off-road vehicles in wilderness areas. Department of Mechanical Engineering, University of Adelaide, Australia, 19 pp.

Richens, V.B., and G.R. Lavigne. 1978. Response of white-tailed deer to snowmobiles and snowmobile trails in Maine. The Canadian Field Naturalist. 92:334-344.

Rivers, K.E., and Menlove, M., 2006. *Winter Recreation on Western National Forest Lands; A Comprehensive Analysis of Motorized and Non-Motorized Opportunity and Access*. Winter Wildlands Alliance, Boise, Idaho.

Rogers, H.H., and Campbell, J.C., 1979. Nitrogen-15 dioxide uptake and incorporation by *Phaseolus vulgaris* (L). Science 206: 333-335.

Rongstad, O.J., 1980. Research needs on environmental impacts of snowmobiles. *In* R.N.L. Andrews and P. Nowak, editors. Off-road vehicle use: A management challenge. U.S. Department of Agriculture, Office of Environmental Quality, Washington, D.C.

Rowe, B., Milner, R. Johnson, C., and Bota, G., 1992. Snowmobile-related deaths in Ontario: a five year review. Can. Med. Assoc. J. 146: 147-152.

Rowe, B., Milner, R. Johnson, C., and Bota, G., 1994. The association of alcohol and night driving with fatal snowmobile trauma: a case control study. Annual Emergency Medacine 24: 842-848.

Ruzycki, J., and Lutch J., 1999. Impacts of Two-Stroke Engines on Aquatic Resources. National Park Service: Effects of Winter Recreation on Wildlife: 145-147. Available: www.nps.gov/yell/publications/pdfs/wildlifewinter/issuesimpacts.pdf

Saber, P.A., and W.A. Dunson. 1978. Toxicity of bog water to embryonic and larval anuran amphibians. Journal of Experimental Zoology 204:133-142.

Schindler. D.W., Mills, K.H., Malley, D.F., Findlay, D.L., Shearer, J.A., Davies, I.J., Turner, M.A., Lindsay, G.A., and Cruikshank, D.R. 1985. Long-term ecosystem stress: The effects of years of experimental acidification on a small lake. Science 228:1395-1401.

Schwartz, S.S., Pakrovski, A.V., Istchenko, V.G., Olsnjev, V.G., Ovtschinnikova, N.A., and Pjastolova, O.A., 1964. Biological peculiarities of seasonal generations of rodents with special reference to the problem of senescence in mammals. Acta Theriologica 8:11-43.

Severinghaus, C.W., 1947. Relationship of weather to winter mortality and population levels among deer in the Adirondack region of New York. Transcript. North American. Wildlife. Confrence. 12:212-223.

Severinghaus, C.W. and Tullar, B.F. 1978. Wintering Deer versus Snowmobiles. New York State Department of Environmental Conservation.

Shaver, C., Morse, D., and O'Leary, D., 1998. Air Quality In the National Parks. U.S. Department of the Interior, National Park Service, Air Quality Division. Report prepared by Energy and Resource Consultants, Inc., NPS Contract No. CX-0001-4-0054.

Snook, 1997. "Carbon Monoxide Exposure by Snowmobile Riders," National Park Science, Vol. 17.

Soininen, L., and Hantula, L., 1992. Snowmobile accidents in Lapland. Arctic Med. Res. 51: 564-570.

Stangl, J.T., 1999. Effects of Winter Recreation on Vegetation. National Park Service: Effects of Winter Recreation on Wildlife:119-121.

Taylor, G.E., Ross-Todd, B.M., and Gunderson. C.A., 1988. Action of ozone on foliar gas exchange in Glycine max (L.) Merr.: a potential role for endogenous stress ethylene. New Phytologist. 110: 301-308.

Thompson, R.D., Grant, C.V., Pearson, E.W., and Corner, G.W., 1968. Cardiac response of starlings to sound: effects of lighting and grouping. American Journal of Physiology 214:41-44.

Tjärnlund, U., Ericson, G., Lindesjöö, E., Petterson, I., and Balk, L., 1995. Investigation of the biological effects of 2-cycle outboard engines' exhaust on fish. Marine Environmental Research. 39:313-316.

Tjärnlund, U., Ericson, G., Lindesjoo, E., Petterson, I., Akerman, G., and Balk, L., 1996. Further studies of the effects of exhaust from two-stroke outboard motors on fish. Marine Environmental Research 42(1):267-271.

Trochta, D., 1999. Effects of Snowmobiling Across Open Water on Fish and Wildlife. National Park Service: Effects of Winter Recreation on Wildlife: 161-162.
Available: www.nps.gov/yell/publications/pdfs/wildlifewinter/issuesimpacts.pdf

U.S. Department of Agriculture/Forest Service, 2001. Species Conservation Project. U.S. Forest

Service Rocky Mountain Region. Golden, CO.
Available: http://www.fs.fed.us/r2/projects/scp/sensitivespecies/index.shtml

U.S. Department of the Interior/National Park Service, 1983. Yellowstone National Park Natural Resources Management Plan and Environmental Assessment.

U.S. Department of the Interior/National Park Service, 1990. Winter use plan and environmental assessment. Yellowstone and Grand Teton National Parks and John D. Rockefeller Jr. Memorial Parkway.

U.S. Department of the Interior/National Park Service, 2000. Final Winter Use Plan, Final Environmental Impact Statement. Yellowstone National Park.

U.S. Department of the Interior/National Park Service, 2003. Draft Backcountry Management Plan: Denali National Park and Preserve, Alaska. Chapter 4: Environmental Consequences.

U.S. Forest Service/National Park Service. 1996. Regional Assessments -- What We Learned and How We are Using Them." Air Resource Management Quarterly Newsletter.

Vitterso, J., Chipeniuk, R., Skar, M., and Vistad, O., 2004. Recreational Conflict Is Affective: The Case of Cross-Country Skiers and Snowmobiles. Leisure Sciences. 26:227-243.

Vos, D.K., Ryder, R.A., and Graul, W.D.,1985. Response of breeding great blue herons (Ardea herodias) to human disturbance in north central Colorado. Colonial Waterbirds 8(1):13-22.

Waller, J.A., and Lamborn, K. R., 1975. Snowmobiling: characteristics of owners, patterns of uses and injuries. Accid. Anal. Rev. 7: 213-223.

Wanek, W.J., 1971a, Observations on snowmobile impact. The Minnesota Volunteer. 34(109):1-9.

Wanek, W. J., 1973. The Ecological Impact of Snowmobiling in Northern Minnesota. The Center for Environmental Studies. Bemidji State College, Bemidji, MN. Pp.57-76.

Wanek, W.J., Undated. The ecological impact of snowmobiling in northern Minnesota. Environmental Impact Studies. Division of Science and Mathematics, Bemidji State College, Bemidji, Minnesota.

Warwick, K.R. and Taylor, G., 1995. Contrasting effects of five native herbs which coexist in calcareous grassland. Global Change Biology 1: 143-151.

Weinstein, M., 1978. Impact of Off-Road Vehicles on the Avifauna of Afton Canyon, California.
Bureau of Land Management. Department of the Interior. Final Report #CA-060-CT7-2734.

Wettersten, R., 1971. Environmental impact of snowmobiling. Pages E-10 - E-13 *in* R.W. Butler, P.S. Elder, H.N. Janish, and B.M. Petrie, editors. Conference on Snowmobiles and All-terrain Vehicles. University of Ontario, London, Ontario, Canada.

Wildlife Conservation Society, 2007. Greater Yellowstone Wolverine Program: Cumulative Report. Wildlife Conservation Society, Ennis Montana.

Wilshire, H.G., Bodman, G.B., Broberg, D., Kockelman, W.J., Major, J., Malde, H.E., Snyder, C.T., and Stebbins, R.C., 1977. Impacts and management of off-road vehicles. The Geological Society of America. Report of the Committee on Environment and Public Policy.

Winner, W.E., and Atkinson, C.J., 1986. Absorption of air pollutants by plants and consequences for growth. Trends in Ecology and Evolution 1:15-18.

Winter Wildlands Alliance, 2009. *Seeing The Forest and The Trees: Assessing Snowmobile Damage in National Forests.*

Wyoming Game and Fish Department (WG&FD), 2003. A Comprehensive Wildlife Conservation Strategy for Wyoming. Wyoming Game and Fish Department Cheyenne, Wyoming. Available: http://www.wildlifeactionplans.org/pdfs/action_plans/wy_action_plan.pdf

Comment Letter #5: Elizabeth Norton

From: Elizabeth Norton [bobliz@frontiernet.net]
Sent: Saturday, October 23, 2010 4:55pm
To: OSVProgramEIR@parks.ca.gov

I would like to receive a hard copy and CD of all the above documents (EIR, App. A and Maps). It is much bigger than my printer is able to handle.

Please send to:

Elizabeth Norton
PO Box 1651
Susanville, CA 96130

Thank you.

Comment Letter #6: Byron Baker

From: Byron Baker [sierrasledder@gmail.com]
Sent: Tuesday, October 26, 2010 10:26 pm
To: OSVProgramEIR@parks.ca.gov

To: Connie Latham, Project Manager:

Hi Connie:

I am a member of the Sierra Buttes SnowBusters, snowmobiling club. We are located in the Bassetts/Gold Lake area.

Many volunteers groom the trails in the Sierra County area.

Page 40 of the attached document indicates that we are to receive a new snow cat in 2011.

Table 2-5. OHMVR Division Snowcat Vehicle Fleet Replacement Plan
2011 Vehicle Replacement Tahoe NF, Bassetts PB300

Our current snowcat is in poor state of repair and we cannot get the State or the Forest Service to approve funding to have it serviced.

Could you find out an approximate date when we can expect to receive the new equipment?

Also, we will require a snow cat with a blade that has a smaller (in width) blade to allow us to navigate the narrower trails in the area.

Thank you so much for your assistance,

Byron E. Baker
916-365-6180
Byron

Comment Letter #7: Michael Evans

From: Michael E. Evans (Guarantee Electrical) [Michael.Evans3@valero.com]
Sent: Thursday, October 28, 2010 11:18am
To: OSVProgramEIR@parks.ca.gov

It would be a great achievement to get a trail cut and groomed to the LTS trail system from the Cisco Grove campground. It would make access easier for Sacramento based riders and open areas that are otherwise a challenge to reach. Just my thought! Thank you, Mike Evans (CNSA, West Coast Sledders and Sacramento Sno-busters member).

Mike Evans

Comment Letter #8: Paul Juhnke

From: Paul Juhnke [pwjuhnke@gmail.com]
Sent: Thursday, October 28, 2010 7:57pm
To OSVProgramEIR@parks.ca.gov

Connie Latham, Project Manager;

I urge you to support Cisco Grove snowmobile trail grooming. It's a fun family sport that encourages healthy living and responsible wilderness use. Un-groomed trails are dangerous.

Thanks,
Paul Juhnke

Comment Letter #9: Bill Harbaugh

From: Bill Harbaugh adrenalineps.com [redlinebill@yahoo.com]
Sent: Thursday, October 28, 2010 9:05pm
To: OSVProgramEIR@parks.ca.gov

Connie; in reviewing the over the snow program I see the lack of Cisco Grove in the grooming program, this is a surprise since it is probably the heaviest used trail system for anyone coming from Sacramento and points west. China Wall is much less used, mainly because they do not receive as much snow as Cisco Grove, yet has full support. Couldn't some of the funding be taken from China Wall and diverted to Cisco Grove?

Thanks,
Bill

Comment Letter #10: Steve Moulis

From: Steve Moulis [steveandkelly@comcast.net]
Sent: Sunday, October 31, 2010 9:12am
To: OSVProgramEIR@parks.ca.gov

Mrs. Latham,

I am taking time to write you in hopes that your office will use some of the OHV fees collected to groom and support the owner of the Cisco Grove Resort.

The owner, Rick, has been grooming the trail for years at great personal expense.

Any support your office can provide is appreciated.

Thanks you,
Steve Moulis
Moderator: www.WestCoastSledders.com

Comment Letter #11: Steve Rounds

From: Steve Rounds [srounds@socal.rr.com]
Sent: Monday, November 1, 2010 9:37pm
To: OSVProgramEIR@parks.ca.gov

Hello
Me and my family are in favor of this Program. Each year we drive to many of the California sno parks to ride our snowmobiles. It is a 6-8 hour drive that we do 7-8 times

each year. Each trip can easily cost us $400.00 to $600.00 dollars which goes directly into the local economy. Lodging, food, and gas are our major expenses.

Without these Snow parks we would be forced to travel out of state to enjoy the sport of snowmobiling.

Thank You for your time

Steve and Susan Rounds
Tustin California 92705

Comment Letter #12: Jeff Erdoes

From: Jeff Erdoes [jefferdoes@att.net]
Sent: Monday, November 22, 2010 1:06 PM
To: OSVProgramEIR@parks.ca.gov
Subject: Re: OSV project DEIR comment

November 21, 2010

California Department of Parks and Recreation
Connie Latham
Project Manager
Over Snow Vehicle Program

Dear Program Manager:

Thank you for the extensive analysis of your Over Snow Vehicle Program grooming proposal for years 2010-2020.

After reviewing your Draft Environmental Impact Report, I decided, at this late hour, to express two of various concerns I have with the draft and with implications of the proposed program. So thank you in advance for accepting my personal observations and comment via email.

The DEIR improperly dismisses aesthetic concerns

#12-1

from DEIR 10.5.1 Aesthetics (pg 226):
" OSV tracks, even in areas of more concentrated off-trail open area use, are also a negligible and temporary change in visual character as compared to undisturbed snow."

Though scarce and ephemeral, expanses of undisturbed snow constitute a singularly valuable resource in the Sierra Nevada. The visual and physical quality of snow scapes and snow surfaces is a major determinant of the quality of the snow-season recreation

#12-1

available to forest visitors, whether motorized or self propelled. For many, attainment of undisturbed snow and untrammeled winter scene is the central motivation behind their forest visit.

Up to 30% of surveyed snow motorists would continue to use trailheads in the absence of grooming services. This suggests that for many recreational snow motorists, groomed snow trails are not so much a goal in themselves as they are a convenience and aid in the pursuit of undisturbed snow.

Undisturbed fallen snow is so beguiling that motorists will drive farther afield, and sometimes willingly out of bounds, to access and impress it. Motorized competition for undisturbed snow undoubtedly explains some of the demand for more and more powerful snowmobiles. The fact that some snowmobiles are now optimized for off-trail use - made to cut tracks afresh rather than share existing lanes - demonstrates the allure of undisturbed snow to specialty motorists and the paradox that leads snow motorists to complain of snowmobile 'crowding'.

Visual and physical availability of undisturbed snow is also of central importance to snow-season visitors traveling by their own power, whether snowshoeing near trailheads or skiing along the Pacific Crest National Scenic Trail. Slopes of undisturbed snow are esteemed for their inspiring beauty and for their suitability for measured and reliable ascent and descent.

Once an open off-trail expanse of natural snow has been impressed with troughs and marks of omnidirectional vehicular play, the visual and physical impacts may endure until a later snow fall restores natural contours to the surface, or until spring. In the meantime, the sharp-edged snow ruts of a snowmobile may persist, frozen in place, sometimes for weeks at a time. The visual impacts, near or far, of rutted snow certainly extend to snow motorists, and in the context of a 14-week snow season, persistent visual impacts and physical impediments posed by fall-line snow ruts are significant in their potential to degrade the rewards of ordinary, self-propelled (self-limited) recreational pursuits.

Without mitigation or restraint, the off-trail snowmobile activity engendered by OSV trail grooming services can be expected to diminish both the attractiveness and the utility of Sierra snowscapes widely in vicinity of groomed trails. Unable to overreach snowmobiles in pursuit of undisturbed snow, the proposed grooming project promises to put the rewards of undisturbed snow out of reach to ordinary forest visitors without specialty vehicles.

The DEIR underestimates future snowmobile emissions

#12-2

From DEIR, page 84:
"As emissions controls take effect, the OSV user fleet at trail sites in the Project Area will show increased use of four-stroke engines or advanced two-stroke engines; it is likely that

#12-2

emissions will be reduced by roughly half of current rates by 2020."

I believe that this expectation is unfounded and overly sanguine.

The US EPA allows significantly looser (more permissive than mfg 'fleet avg') HC and CO emissions standards for specialty - high powered two-stroke - snowmobiles. High-output two-strokes are precisely the OSV most likely to leave the trail system and release outsized and indeed unregulated exhaust in off-trail locations. Even after three years of EPA standards by the 2009 survey, more than 96% of California OSV were still two-stroke - an inconsequential improvement.

Moreover, EPA exhaust limits for snowmobile HC and CO emissions are specified in grams of pollutant per kilowatt-hour, aka grams per hourly throttle level. As more and more powerful snowmobiles arrive on the public commons, average horsepower expended per visit has been rapidly increasing. One prominent measure of this is expanded hillside loop-driving.

Applying more horsepower (more throttle), converts fuel into exhaust more rapidly, increasing emissions per unit of time. In this way, a brand new 'updated' high-power EPA 2012-compliant OSV operated for one hour at 48 average horsepower actually releases MORE hydrocarbon (11.9 lbs vs 11.2 lbs) and MORE carbon monoxide (31.7 lbs vs 30.7 lbs) in remote locations per visit than an typical 1998 two-stroke snowmobile* operated one hour at 36 average horsepower.

#12-3

Exhaust emissions from the 'average privately owned snowmobile' which will be used in California mountains into the forseeable future may be even greater than those quantified for this comparison for several reasons:

- Once a snowmobile is in service, mechanical wear accrues to its engine and drive train; its operating efficiency drops off and its average exhaust emissions increase to some extent
- Once a snowmobile is sold into private ownership, no federal or state limits apply to its exhaust emissions; there is, at this time, no dependable curb on emissions from degraded or maladjusted snowmobiles in private hands
- Existing snowmobiles which were manufactured without respect to pollution restraints will continue in service indefinitely, at any owner's discretion
- Snowmobiles which run cleaner than the final (2012) EPA standards are likely to continue to be more expensive (for equivalent horsepower) than snowmobiles which merely meet the standard
- Snowmobiles spread a greater variety of noxious waste than just the HC and CO pollutants examined in this comparison

With, in fact, no emissions controls on private OSV activity, and with a 10 year activity growth forecast to 148% of baseline, off-trail and even on-trail snowmobile emissions could actually increase over the project lifetime. This increase is partly reflected in table 4-13 (pg 104) which indicates prospective growth in project-related snowmobile emissions.

Unrelenting and unregulated large-scale snowmobile emissions magnify concerns of contamination accumulating in sensitive environments and are also likely to stimulate use conflicts between snowmobile motorists (who are increasing their average expenditure of horsepower every season), and between lung-reliant visitors pursuing wholesome atmosphere and motorists.

Respectfully submitted,

Jeff Erdoes
Carson City, Nevada

*using NPS-determined two-stroke snowmobile emissons factors - averaged from two 1998 and a one 1999 snowmobile - presented in February, 2000, "Air Quality Concerns Related to Snowmobile Usage in National Parks" report, Appendix pg A-3, baseline snowmobile emissions determined by SwRI:
HC = 141 g/hp-hr   CO = 386 g/hp-hr

US EPA 2012 max allowable emissions from new-made snowmobiles:
HC = 150 g/kW-hr   CO = 400 g/kW-hr
http://www.epa.gov/EPA-AIR/2008/June/Day-25/a14411.pdf
also
http://www.epa.gov/fedrgstr/EPA-AIR/2008/June/Day-25/a14411.htm

Exhaust per hour at 48 horsepower at EPA 2012 snowmobile max allowance, grams converted to pounds:

150 g/kW-hr X .75 hp/kW X 48 hp = 5400 g/hr   5400 g/hr X 1 lb/453 g = 11.9 lb/hr
That is 11.9 lbs of hydrocarbon per hour at 48 horsepower

400 g/kW-hr X .75 hp/kW X 48 hp = 14,400 g/hr   14,400 g/hr X 1 lb/453 g = 31.7 lb/hr
That is 31.7 lbs of carbon monoxide per hour at 48 horsepower

Exhaust per hour at 36 horsepower from average 1998 two-stroke snowmobile, grams converted to pounds:

141 g/hp-hr X 36 hp = 5076 g/hr   5076 g/hr X 1 lb/453 g = 11.2 lb/hr
That is 11.2 lbs of hydrocarbon per hour at 36 horsepower

386 g/hp-hr X 36 hp = 13,896 g/hr   13,896 g/hr X 1 lb/453 g = 30.7 lb/hr
That is 30.7 lbs of carbon monoxide per hour at 36 horsepower

ORAL COMMENTS
(Received at OHMVR Division Public Meeting on October 27, 2010)

Commenter #13: Patrick Lieske, Lassen National Forest, Wildlife Biologist

Comment #13-1: Effectiveness of USFS monitoring efforts for goshawk PAC may not be fully addressing impacts related to OSV use. USFS monitoring of PACS is related to timber sales not OSV use near trails.

Comment #13-2: OSV use still occurs on the forest even when low snow conditions exist and winter trails are closed for the season by forest order.

Comment #13-3: EIR mitigation measures may require additional funding for USFS to implement.

Commenter #14: Byron Baker

Comment #14-1: Snowcat operated at Bassetts needs to be replaced. Bassetts would have more volunteer groomers if snowcat equipment was reliable.

Comment #14-2: Limited parking is available at Bassetts trailhead. When parking at Yuba Pass fills up, overflow parking spills over to Bassetts. When Bassetts trailhead parking is full, it spills over to the parking area used by residents of Green Acres subdivision. There is room to expand Yuba Pass parking area and this could alleviate OSV parking shortage affecting Green Acres residents.

2.0 RESPONSE TO COMMENTS

Written Comments Received on OSV Program Draft EIR, Program Years 2010 – 2020

Comment Letter #1. Lassen National Forest

Comment #1-1: Increased indirect costs to U.S. Forest Service from increased OSV use.

Response to Comment #1-1: As noted, the OSV Program Draft EIR (Section 2.7.2.1) does assume OSV growth could occur during the 10-year project period. An annual average growth level of 4% is used in the environmental analysis to project potential OSV use levels in 2020. This growth level is based on historical increases in snowmobile registrations that have occurred over the previous decade. The number of registrations peaked in 2008 and has declined in 2009 and 2010, which could mark the beginning of a downward trend (see Attachment B). Thus, the 4% growth analysis used in the Draft EIR is conservative and serves to define a maximum use level for purposes of environmental analysis.

The Draft EIR does not assume expansion of the OSV Program to provide new recreation opportunities (new trail systems) is necessary but rather acknowledges the possibility it could occur and addresses potential environmental effects of operating (but not developing) an expansion. More specific effects would have to be analyzed at the time new trail systems are actually proposed and specific project details are known.

If growth in OSV recreation occurs or if OSV Program operations expand to new locations, it could result in increased need for law enforcement and resource monitoring efforts by the USFS. It is recognized there is a cost associated with providing new or expanded services. It is not known whether growth in OSV recreation or the operation of the OSV Program, as projected in the Draft EIR (Sections 2.7.1 and 2.7.2.1) for the purposes of environmental analysis, will actually occur. Measures LU-1 and REC-1, presented in the Draft EIR, require increased law enforcement where the need is made evident from monitoring efforts. Both measures specifically state both the OHMVR Division and USFS shall work to address the issues that arise through monitoring efforts. Provision of adequate law enforcement is the responsibility of the USFS. However, the OHMVR Division recognizes there may be instances where supplemental state funding may be possible; this would be evaluated by the OHMVR Division on a case-by-case basis.

Implementation of all EIR mitigation measures requires a collaborative effort between the OHMVR Division and the USFS regional office and national forests. Regardless of how the mitigation measures are funded, it is the responsibility of the USFS to implement the measures required as a condition of the contract agreement between the OHMVR Division and each national forest. Failure to implement the EIR mitigation measures would be a violation of the terms of the agreement and would result in state withholding of contract funds until it is demonstrated that the mitigation is implemented. As stated in Draft EIR Section 2.9.2:

> “If during the course of its review, OHMVR Division determines that a recipient is not in compliance with the OSV Program requirements, the OHMVR Division would make an administrative finding of non-compliance and would not renew the contract with that agency until compliance can be demonstrated.”

Comment #1-2: Regional focused studies on northern spotted owl and northern goshawk

Response to Comment #1-2: There is no information to date that indicates OSV recreation is adversely affecting northern goshawk or northern spotted owl. OSV use has been occurring in the Project Area over a long period of time (at least 14 years at all locations and longer in many). Both northern goshawks and spotted owls are long-lived birds with very high site fidelity. Pairs and individuals return to the same territory every year. Once adults establish a territory, they use that territory for the remainder of their life unless the habitat becomes unsuitable through destruction or high levels of disturbance. Given that birds have co-existed with OSV use for a long time and continue to nest in their established territories, no evidence has been provided indicating these birds are significantly impacted by OSV activity given implementation of USFS Management Actions. Therefore no mitigation is necessary because the level of impact is less than significant.

The USFS has Management Actions concerning these species as listed in the Draft EIR, Table 5-5. Regional focused studies on the northern goshawk and northern spotted owl are being completed, and the collected data once published will allow the USFS to adjust implementation of Management Actions as needed to address significant disturbance to northern goshawk or northern spotted owl reproductive behavior. For example, the USFS may determine that a Limited Operating Period (LOP) needs to be initiated earlier in the season or that additional monitoring is warranted.

The environmental analysis in the Draft EIR does not presume the biological studies will conclude there is no effect of OSV recreation on these species. Rather, the Draft EIR concludes the USFS has the ability to implement Management Actions as needed, such as trail closures or LOPs, to protect these species from significant impacts. The USFS employs adaptive management and consistent with that approach, USFS biologists will review the results of the focused studies and site-specific information related to a specific individual or pair such as observations of individuals being disturbed (e.g., owl or goshawk flying off of nest or roost) as OSV use occurs; evidence of nest failure that appears to be linked to OSV use; proximity of the OSV use to known nests, overlap of timing of OSV use with reproductive season, and local topography. If in their professional judgment, USFS biologists determine that OSV recreation is adversely affecting northern goshawk or northern spotted owl, Management Actions of trail closures or LOPs will be implemented in the area of concern to avoid or reduce the impact to a less than significant level.

In response to these focused studies, Measure BIO-1 requires the USFS to adjust implementation of Management Actions as needed to ensure any significant adverse effects caused by the OSV Program continue to be adequately mitigated.

Comment #1-3: Supplemental monitoring and GIS analysis may be needed at increased cost to USFS.

Response to Comment #1-3: Measure BIO-1 requires that the USFS update the implementation of its Management Actions governing the northern goshawk and northern spotted owl to reflect the most current information as contained in the regional focused studies. The subsequent need for and level of species monitoring the USFS implements may be revised based upon the results of the focused studies. The monitoring measure associated with Measure BIO-1 in the Draft EIR does not require the USFS to perform new monitoring but does require the USFS to adjust implementation of Management Actions based upon focused study results to ensure any significant adverse effects caused by the OSV Program continue to be adequately mitigated. The

USFS must document monitoring efforts undertaken as well as any Management Actions implemented and provide that documentation to the OHMVR Division. Also see response to Comment #1-1.

Comment #1-4: California wolverine impact.

Response to Comment #1-4: California wolverine is not known to occur near project sites (Draft EIR, Page 5-39) and therefore no impact to the wolverine from OSV use is known to be occurring. Although systematic monitoring for the wolverine is not occurring throughout all national forests, the USFS does include wolverine in its annual carnivore monitoring (Draft EIR, Page 5-39). If wolverine is determined to be present by verified sightings, there is a potential for significant impact if OSV use occurs near a natal den. Measure BIO-2 avoids this potential impact by requiring implementation of a LOP.

Comment #1-5: Measure BIO-3.

Response to Comment #1-5: First sentence of Measure BIO-3 is modified as suggested. See Text Amendments (Section 3.0).

Comment #1-6: Measure BIO-3

Response to Comment #1-6: The referenced document, Sierra Nevada Red Fox A Conservation Assessment, was reviewed in preparation of the Draft EIR and cited in the References consistent with CEQA Guidelines § 15148 (see Draft EIR Section 11.1). It is not incorporated by reference pursuant to CEQA Guidelines § 15150, which is generally reserved for long, technical analyses or other documents directly applicable to the project but too long to include fully in the EIR. The USFS is actively working with wildlife biologists from California Department of Fish and Game (CDFG) and University of California Davis to develop a monitoring program for Sierra Nevada red fox. Based on the monitoring results, the USFS will develop Management Actions as needed to address potential effects from OSV activity as reflected in BIO-3. Management Actions will be implemented when, in their professional judgment, USFS biologists determine that OSV activity is disturbing the red fox based on individuals being disturbed, proximity of OSV use to known den sites, overlap of timing of OSV activity with reproductive season, and local topography.

Comment #1-7: Special Status Plant Species Impact

Response to Comment #1-7: Lassen National Forest, along with most of the other national forests participating in the OSV Program, does not have minimum snow depth requirements for OSV use. While OSV Program-sponsored grooming stops by the end of March, OSV use throughout the forest can continue as long as there is snow on the ground unless prohibited by a minimum snow depth requirement enforced by a Forest Order. As noted, OSV recreation may continue into April and possibly May dependent upon snow conditions. Because off-trail riding can occur in low snow conditions, special-status plant species could be adversely affected. Measure BIO-4 addresses this potential impact by requiring national forests to implement any of the following: 1) restrict OSV use in low snow conditions, 2) locate by survey and protect plant species at risk of being impacted by OSV use, or 3) conduct annual monitoring where plants have potential for occurring and implement protective measures as needed. With the implementation of this measure, impacts to special-status plants would be reduced to a less than significant level.

Comment #1-8: Soil compaction

Response to Comment #1-8: Soil compaction and erosion impacts from OSV use are addressed in the Hydrology and Water Quality chapter of the Draft EIR (Sections 6.2.3.1 and 6.3.3.1). Snowmobiles exert very little pressure on bare ground even in low snow conditions compared to other forms of recreation (Draft EIR Table 6-2). Soil erosion from OSV use was not observed by the USFS during its end of season monitoring according to the 2009 OSV Program Monitoring Checklists submitted to the OHMVR Division and therefore is not considered a significant impact. All national forests were contacted during the preparation of the Draft EIR. Soil disturbance or erosion from OSV use was not identified as a significant issue of concern.

Comment #1-9: Table S-1, all Mitigation Measures

Response to Comment #1-9: The comment does not address the sufficiency of analysis of a significant project impact or the identified EIR measures to mitigate or avoid those impacts. Implementation of the EIR mitigation measures requires a collaborative effort between the OHMVR Division and the USFS regional office and national forests. The OHMVR Division will work with the USFS to determine whether work plans must be modified or expanded and identify opportunities for additional funding. Regardless of whether existing USFS work plans need to be modified, the EIR mitigation measures must be implemented to reduce the significant impacts of the OSV Program to a less-than-significant level. If mitigation measures are not implemented, the OSV Program contract funding would be withheld. See response to Comment #1-1.

Comment #1-10: Table S-1, all Mitigation Measures

Response to Comment #1-10: As noted, Measures BIO-3, BIO-4 and BIO-5 require resource monitoring due to potential impacts from OSV activity and possible implementation of protective measures dependent upon monitoring results. As stated previously, implementation of the EIR mitigation measures requires a collaborative effort between the OHMVR Division and the USFS regional office and national forests. See response to Comments #1-1 and #1-9.

Comment #1-11: One-time funds of $227,445

Response to Comment #1-11: The funds issued through the Grants Program shown in Draft EIR Table 2-11 were for equipment or vehicle purchases and repairs, facility maintenance (e.g., restrooms, signage, and kiosks), and additional staff to assist with facility maintenance, public contacts, and resource monitoring. Of the total one-time funds, $31,000 on the Tahoe National Forest was specifically targeted for resource monitoring purposes. This included funding to provide for a wildlife biologist, botanist, archaeologist, soil scientist, and other specialists to monitor OHV/OSV use in sensitive and/or heavily used areas (e.g., meadows, areas with high concentrated OSV use) and related areas of concern that are off trail.

The OHMVR Division has provided substantial funding to the USFS to conduct the northern goshawk and northern spotted owl regional focused studies. The USFS also expends internal funds on annual monitoring efforts throughout the national forests. The Division acknowledges there are costs associated with implementing the mitigation measures identified in the EIR. Please see response to Comments #1-1 and #1-9 above.

Comment #1-12: OHMVR Division compliance review

Response to Comment #1-12: Based on the environmental analysis contained in the OSV Program EIR, new monitoring and resource protection measures have been specified where needed in addition to ongoing efforts already underway in the forests. These measures outline the monitoring requirements for each national forest to be in compliance with the OSV Program. These requirements, as identified in the EIR, will be incorporated into the contract agreement between the OHMVR Division and each national forest. Existing agency protocols (e.g., monitoring methods, frequency, location, etc.) will be used to implement the monitoring component of these mitigation measures. Protocols typically change as new information becomes available. New protocols may be developed based on results of pending studies (i.e. focus studies on northern goshawk and northern spotted owl; and monitoring of the Sierra Nevada red fox).

Comment #1-13: Grants Funding on Table 2-11

Response to Comment #1-13: Of the funds from the Grants Program awarded to national forests for OSV Program related activities, only funds to Tahoe National Forest were allocated for resource monitoring (see response to Comment #1-11). As noted, the resource monitoring required to implement the mitigation measures specified in the OSV Program EIR may involve work which is outside the scope of existing forest-level biological programs. The OHMVR Division is aware of the additional costs associated with implementation of the EIR mitigation measures and will work collaboratively with the USFS to ensure adequate funds are available (see response to Comments #1-1 and 1-9). As stated in response to Comment #1-12 above, specific monitoring protocols used to implement these mitigation measures will be determined by discussions between OHMVR Division and USFS staff prior to implementation.

Comment #1-14: Growth in OSV Recreation reference to Measure BIO-3

Response to Comment #1-14: The reference to Measure BIO-3 on page 3-17 of the Draft EIR is in error. The mitigation measure addressing impact to sensitive plant species potentially impacted by OSV is Measure BIO-4. This reference is corrected in Text Amendments. As noted, off-trail riding is permissible on Lassen National Forest and since Lassen National Forest does not have a minimum snow depth requirement, the forest would be responsible for implementing paragraph 2 or 3 of Measure BIO-4 to be found in compliance.

Comment #1-15: Wildlife Movement Corridors

Response to Comment #1-15: Section 5.2.6 of the Draft EIR presents an environmental setting discussion of wildlife movement corridors. The discussion of project impacts to wildlife corridors is presented in Section 5.3.2.4 and 5.3.3.3. The discussion concludes that funding the existing OSV Program would not change the groomed trail system, which occurs on an existing road network and has been in existence for many years, and therefore would not impact wildlife corridors. If the OSV Program is expanded to include new trail systems, the new trails would be subject to environmental review at the time they are proposed. The potential for impact to wildlife corridors would be evaluated at that time.

Comment #1-16: Table 5-5, Northern Goshawk and California Spotted Owl

Response to Comment #1-16: Current USFS Management Actions include both monitoring *and* LOPs and route closures/reroutes to address potential disturbance to northern goshawks and spotted owls (northern and California). The Draft EIR (Pages 5-36 – 5-38) found the combination of these protocols adequate to ensure the impacts of the OSV Program on these species are less than significant. National forests have implemented LOPs in the past for these species. According to the USFS Regional Office, a number of national forests have established LOPs for OHV use, including the Lassen, Eldorado, Sierra, Plumas, and Mendocino National Forests. These LOPs address special events (enduro events), all OHV use in general, or specific routes added to the National Forest Transportation System in the recent Travel Management Decisions (e.g., Lassen and Plumas National Forests). Forests may use other Management Actions besides LOPs. At least one forest (Stanislaus National Forest) dropped routes near spotted owl nests in the Travel Management decisions because of concerns regarding proximity to a nest. LOPs for OSV activity specific to northern goshawk and spotted owls are available to the forests but mostly unnecessary because of other closures on the forests during the beginning of the nesting season (e.g., deer winter areas, bald eagle closures, or the area is just not accessible to over snow use during the nesting season).

Presence/absence monitoring conducted over time is beneficial for establishing a history of bird presence. The northern goshawk and spotted owls are territorial species nesting in the same area year after year. The nesting sites for these species are known and presence/absence monitoring indicates if a disruption has occurred and the nest is no longer active. Given an absence, assumptions can be made about the reason for the disappearance and whether it can be attributed to a specific activity that needs to be removed from the nesting area. A different monitoring method is behavior monitoring which evaluates an individual's response to a disturbance activity. The Regional Northern Goshawk and Regional Northern (not California) Spotted Owl Focused Studies being conducted by the USFS are based on behavior monitoring and would indicate if these species are susceptible to disturbance from OSV/OHV related activity. The results of these studies would provide the USFS with data it needs to determine whether LOPs or other Management Actions need to be implemented on the national forests to protect these species.

In consideration of ongoing research and the potential development of new data over the 10-year life of the project, the EIR takes an adaptive management approach. EIR Measure BIO-1 thus requires that the USFS report and incorporate any changes in northern goshawk or spotted owl Management Actions, including changes resulting from the focused studies, into the OSV Program requirements.

Comment #1-17: Redirection of Grooming Funds Alternative

Response to Comment #1-17: The commenter notes that this alternative could provide a source of funds for resource monitoring. No specific comments were made on the adequacy of the alternative analysis. No further response is required.

Comment #1-18: Redirection of Grooming Funds, last paragraph

Response to Comment #18: The extent to which grooming is reduced by this alternative would depend upon the amount of funds redirected on each forest. The effect of reduced grooming on trail conditions would again depend upon what level of decrease in grooming activity occurs. This has not been determined. The sentence has been revised. See Text Amendments.

Comment #1-19: Environmentally Superior Alternative

Response to Comment #1-19: Comment acknowledged. The Draft EIR concludes the Funding of Restricted Riding Areas Only alternative is the Environmentally Superior Alternative. As noted in the comment and discussed in the Draft EIR, OSV use would likely be reduced by this alternative and the redirection of OSV riders would likely create a need for increased law enforcement patrols and public outreach to enforce trail riding restrictions. This alternative would limit funding to only those forests which have off-trail riding restrictions. As noted, under this alternative individual national forests would have to amend their forest plans in order to receive OSV Program funds.

Comment #1-20: OSV Program Monitoring Report Per EIR Data Request

Response to Comment #1-20: Lassen National Forest provided supplemental monitoring report information for consideration in the OSV Program EIR. The monitoring report does not directly comment on the sufficiency of the environmental analysis presented in the Draft EIR. The information presented in the monitoring report does not identify new environmental impacts or change the analysis and conclusions contained in the Draft EIR. As such, no further response to this document is required.

The monitoring report concludes with a recommendation that the grooming program not extend beyond March 31. While this is not a direct comment on the Draft EIR, it should be noted the grooming operation generally occurs between mid-December through the end of March (Draft EIR Section 2.4.1). It should also be noted that cessation of grooming does not stop OSV activity on the forest. OSV recreation may continue into April or even May dependent the availability of snow. Thus, the potential for OSV activity to overlap with the breeding season of special-status raptors being monitored on the Lassen National Forest remains regardless of the end of the grooming activity.

Comment Letter #2. Center for Biological Diversity

Comment #2-1: Incorrect baseline shields impacts from review

Response to Comment #2-1: As noted by the comment, an EIR "must include a description of the physical environmental conditions in the vicinity of the project, as they exist at the time the notice of preparation is published… This environmental setting will normally constitute the baseline physical conditions by which a lead agency determines whether an impact is significant." (CEQA Guidelines § 15125(a).) Baseline is often commonly referred to as existing conditions.

The Draft EIR is using the term baseline in a slightly different context. Because changes in the OSV Program, such as the number of recreationists, are foreseeable over the 10-year Program life, the Draft EIR analyzes program impacts at both the Program start (winter 2010/11) and Program end (winter 2020/2021). Project conditions and impacts at the start of the OSV Program are referred to as "Project Baseline, Year 2010." Both impact analyses for years 2010 and 2020 utilize existing pre-project environmental conditions as the CEQA baseline for assessing environmental impacts of the project and thus for the selection of alternatives. This approach provides a more complete analysis for reviewers: what would the initial impacts be from implementing the project under the conditions as they exist today (Project Baseline, Year 2010), and what might the impacts of the project be in 10 years (Project Growth Year 2020)? It is important to note the environmental baseline conditions used to assess project impacts include existing features utilized by the OSV Program. For example, the roads groomed and parking areas plowed as part of the proposed OSV Program are existing infrastructure used by motorized vehicles and recreationists throughout the year. Their prior development is not the subject of the EIR (the EIR also does not evaluate site-specific impacts from developing new trail systems or parking areas). In sum, the EIR is considering the effects of the activities directly funded by the OSV Program and OSV recreation facilitated by those activities.

As described in the No Project Alternative discussion, OSV recreation itself is an ongoing and allowable use of the Project Area that would continue even without state funding, albeit at lower levels. As noted in Draft EIR Section 2.6.1.2, one-third of existing OSV activity would occur without the OSV Program. Thus, the correct existing conditions to be used as a baseline for evaluating environmental effects of the project is not zero OSV activity in the Project Area but rather ongoing OSV use occurring at a reduced level (one-third of existing visitor use levels). Therefore, the OSV activity occurring in the Project Area regardless of the grooming and plowing activity of the OSV Program should be considered when evaluating OSV Program impacts. Furthermore, the description of the OSV Program, and the description of impacts, would be incomplete if it did not acknowledge these seasonal but ongoing activities that have been occurring at all locations for at least 14 years (see Draft EIR section 2.4) and in many cases much longer, but these effects are not dismissed going forward. Rather, the EIR assesses the significance of impacts of the OSV Program and the OSV use facilitated by the OSV Program at these current levels. In places, the EIR text noted no new impacts would occur under the Program as proposed. Because this language may cause confusion, the text has been revised to clarify that the significance evaluation under "Project Baseline, Year 2010" conditions *is* assessing the existing OSV Program (see Section 3.0). The EIR also takes into account existing USFS forest-wide standards and guidelines and other management prescriptions already in effect to mitigate impacts. Thus, although the EIR is not evaluating the impacts of establishing OSV recreation where it has never occurred, it does evaluate the impacts of implementing the OSV Program and of the recreational uses that are expected to occur because of the Program.

Specific to biological resources, the Draft EIR specifically discusses the potential for a myriad of impacts under both "Project Baseline, Year 2010," and "10-Year Program Growth, Year 2020" conditions. In reaching significance conclusions, both analyses properly consider existing USFS Management Actions when determining impact significance. The analyses do not rely on a "no change from current OSV Program" approach, but they do for accuracy reference the activities as ongoing and note whether a change in the activities is anticipated. Please see, for example, the discussion of "Breeding Disruption" on page 5-34, which states "For special-status species, breeding disruption could be a significant adverse impact to a species with an already low population." It is only because of implementation of the USFS Management Actions already in use (Table 5-5) and the adaptive management approach to mitigation (described in Mitigation Measures BIO-1 and 2) that the Draft EIR found breeding disruption to be less than significant. The text further notes no new impacts would occur as a result of the continuation of the OSV Program and therefore, the Project's effect on breeding special-status birds is less than significant. This is a separate significance determination. The text has been amended for clarity (see Section 3.0). Please note also that ongoing uses are relevant to certain species impacts, for example, when discussing habituation, e.g., American marten (see Draft EIR p. 5-38).

The comment also mentions in a footnote CDFG is a trustee agency and questions whether CDFG has provided any input on the EIR to date. CDFG did receive a copy of the 2008 Initial Study/Negative Declaration, 2009 Initial Study/Negative Declaration, Notice of Preparation (NOP; see Draft EIR Appendix H), and Draft EIR for the OSV Program but did not submit any responses to any of these documents. The letter received from the State Clearinghouse stating that no state agencies submitted comments on the Draft EIR is attached with the comment letters in Section 1.0 of the Final EIR. As noted in Draft EIR section 1.3, no permits or other discretionary approvals from regulatory agencies are required for project activities.

Comment #2-2: Range of feasible alternatives

Response to Comment #2-2: The comment provides CEQA statute and case law regarding selection and consideration of alternatives. The comment does not specify a deficiency in the Draft EIR's identification and analysis of significant environmental impacts, on measures to avoid or mitigate those impacts, or in the alternatives considered. Consistent with Public

Resources Code sections 21002, 21002.1(b), and 21081, the OHMVR Division has not proposed a project that would cause unavoidable, significant effects that could otherwise be mitigated by feasible alternatives. All potentially significant impacts have been mitigated to a less-than-significant level as summarized in Table S-1.

Comment #2-3: Project has potential to significantly affect special-status species and wildlife movement corridors

Response to Comment #2-3: Indeed, as discussed in the Draft EIR, the project does have the potential to significantly affect certain special-status species. The potential impacts of the OSV Program on special-status wildlife are discussed in Draft EIR Sections 5.3.2.1 and 5.3.3.1. Mitigation measures are identified in Draft EIR Section 5.4 to reduce those impacts to a less than significant level. The potential impacts of the OSV Program on wildlife movement corridors are discussed in Draft EIR Sections 5.3.2.4 and 5.3.3.3 and are not considered significant. The potential impacts of the OSV Program on special-status plants and aquatic habitat are discussed in Draft EIR Sections 5.3.2.2, 5.3.2.3, 5.3.3.1, and 5.3.3.2, and mitigation is identified in Draft EIR Section 5.4 to reduce impacts to plants and riparian and wetland habitats to a less than significant level. As described in the Draft EIR hydrology/water quality discussion (Sections 6.3.2.1 and 6.3.3.1), OSV use in the Project Area has not resulted in significant soil compaction or soil erosion impacts. It is unclear whether the commenter considers the impact discussion of a particular species or other biological effect to be inadequate as OSV Program impacts to all species listed in the comment are discussed in the Draft EIR. The EIR has been modified to further clarify the potential for impacts to golden eagle (see Section 3.0). Further, the comment does not present any evidence to substantiate its claims that impacts to special-status species, wildlife movement corridors, aquatic habitats, and soils are significant or otherwise contradict the conclusions of the EIR.

Comment #2-4: Draft EIR does not “count” many significant impacts considered part of baseline

Response to Comment #2-4: Existing baseline conditions include the effects of ongoing non-project OSV recreation occurring in the Project Area. Therefore some level of environmental impacts associated with OSV activity is included in the baseline conditions, which cannot be attributed to the OSV Program. As clarified in response to Comment #2-1, the EIR does not discount OSV Program impacts as existing baseline conditions. The Draft EIR acknowledges the potential for impacts to species under both “Project Baseline, Year 2010” and 10-Year Program Growth, Year 2020 conditions. The Draft EIR concluded all potentially significant impacts would be mitigated to a less-than-significant level.

Comment #2-5: Species declining under USFS management

Response to Comment #2-5: Lacking the identification of specific species, it is difficult to address this comment. The current population status of each of the various special-status species is related to specific and often multiple reasons that are not necessarily linked to past or current USFS management of the OSV Program. Contrary to the commenter’s statement, not all of the special-status species on the national forests are "declining," The comment does not provide any description of the substantial evidence or citations of the studies showing the evidence linking the OSV Program and USFS management of OSV recreation to significant impacts on special-status species. Please also see the responses to Comments #2-1 and #2-4 regarding OSV Program impacts to species. The Draft EIR has specified and evaluated those USFS Management Actions relevant to mitigating impacts to specific special-status species (see Tables 5-3 and 5-5), and where those measures were not found adequate to mitigate significant impacts, additional mitigation is required. Please see response to Comment #2-6 regarding the EIR's reliance on USFS management plan policies. Also see response to Comment #1-16 regarding USFS use of LOPs to manage OHV/OSV recreation impacts to special-status species.

Comment #2-6: Not sufficient to rely on USFS management plans to protect plants, wetlands, and other resources; adaptive management is insufficient

Response to Comment #2-6: Impacts to plants, wetlands, and other resources due to compaction, degradation, or in areas where snow is thin and soils are directly affected are directly evaluated in Draft EIR Sections 5.3.2.1, 5.3.2.2, and 5.3.2.3. Mitigation has been included to reduce potential impacts to a less-than-significant level where warranted. It is unclear whether the commenter considers the impact discussion in these sections to be inadequate.

Every national forest or grassland managed by the USFS has a land resource management plan (LRMP) prepared consistent with the National Forest Management Act (NFMA) of 1976 (16 U.S.C. 1604) and other laws, including the federal ESA, and must, among other requirements, provide for the diversity of plant and animal communities. All of the current plans for the national forests in California were established under the 1982 Planning Rule (36 CFR 219.19; see http://www.fs.fed.us/emc/nfma/includes/nfmareg.html), which established an additional requirement to provide for adequate fish and wildlife habitat to maintain viable populations of existing native vertebrate species. In addition, these plans include provisions to address the recovery of federally-listed threatened and endangered species and their habitats and the conservation of USFS Sensitive species and their habitats on National Forest System lands. USFS Sensitive species are species that need special management to maintain and/or improve their status on national forests and grasslands, and prevent a need to list them under the federal ESA. All Management Actions conducted on a national forest must be consistent with the applicable forest plan. The efficacy of the Management Actions in each forest plan was reviewed under the National Environmental Policy Act when each plan was adopted. Specific to CEQA, as noted in the response to Comment #2-6, the Draft EIR has specified and evaluated those USFS Management Actions relevant to mitigating impacts to affected resources, and where those measures were not found adequate to mitigate significant impacts, additional mitigation is required.

Adaptive management, referenced in the Draft EIR only for northern goshawks and spotted owls, is a recognized by trustee and responsible agencies managing biological resources (e.g., CDFG and USFWS) as an accepted approach to biological management. It is reasonable to anticipate biological information from both USFS and other studies will be generated over the 10-year Program life that would affect how best to manage the resources affected by the OSV Program. For example, as discussed in the Draft EIR, data from studies regarding OHV effects on northern goshawks and spotted owls are currently under review. Under adaptive management, as new information is made available, or more effective monitoring strategies are developed, USFS management practices of OSV recreation will change or “adapt” as warranted by the new information. Based upon the data available for the EIR, the monitoring and management approaches described in the EIR, including those measures included as mitigation, ensure adverse impacts are reduced to a less-than-significant level. All mitigation measures are fully enforceable through contract provisions. Measure BIO-1 has been revised to clarify that it is the implementation of existing Management Actions (e.g., LOPs and trail reroutes/closures) that may be adjusted in response to the new focused studies. These Management Actions are sufficient to reduce significant disturbance impacts. See response to Comment #1-2 and Text Amendments (Section 3.0).

Comment #2-7: Available alternatives would avoid and significantly reduce impacts to species

Response to Comment #2-7: Please see response to Comment #2-1 regarding "under-estimated" project impacts. Please see response to Comment #2-2 regarding the selection of alternatives. As noted by the comment, the Draft EIR does identify the Funding of Restricted Riding Areas Only alternative as the environmentally superior alternative (in addition to the No Project alternative). Given that all project impacts are mitigated to a less-than-significant level and that the Funding of Restricted Riding Areas Only alternative does not fully meet the project objectives, it was not chosen in place of the proposed OSV Program.

Comment #2-8: Draft EIR erroneously rejects the Closure of Off-Trail Riding Areas and Prohibition of Two-Stroke Engine alternatives

Response to Comment #2-8: The commenter is correct that the Division could propose not funding grooming and clearing activities in areas where off-trail riding is allowed. That alternative is included in the EIR as the Funding of Restricted Riding Areas Only alternative. Please see response to Comment #2-7 regarding rejection of that alternative. As discussed in Draft EIR Section 9.1.4, banning legal two-stroke engines on OSV Program trails and the broader Project Area is both infeasible and impractical and more properly the subject of state legislation and vehicle codes. As noted, similar to the Funding of Restricted Riding Areas Only alternative, the OHMVR Division could fund only those areas that ban two-stroke engines. However, two-stroke engines are a legal use in the state of California, and national forests are ungated, open lands with multiple points of entry along access roads, trailheads, and private properties. USFS enforcement of a two-stroke engine ban in portions of individual forests when two-strokes are otherwise legal in the remaining (non-OSV Program) areas of the forests and throughout California is problematic. For this reason, a project alternative in which the OHMVR Division funds only of those trails where two-stroke engines are banned is not considered. Furthermore, as there are no unmitigated significant impacts that would be addressed by banning two-strokes, there is no need under CEQA to consider the alternative.

Comment #2-9: Draft EIR cumulative analysis fails to adequately consider impacts of past OSV activities

Response to Comment #2-9: Please see the response to Comment #2-1 regarding the baseline used for assessing project impacts. As acknowledged by the EIR, OSV activities have potential and documented impacts on biological resources. These effects, along with the other activities described in Draft EIR Section 5.3.4, Cumulative Impacts, are considered when determining impacts of the OSV Program. The comment does not state which past OSV Program impacts are cumulatively considerable and does not identify other projects adding to cumulative effects that should be assessed in the EIR analysis.

The comment provides no evidence of past OSV Program activities having contributed to a declining status of species in the Project Area. See also response to Comment #2-5.

Comment #2-10: Draft EIR identification and analysis of impacts to biological resources is inadequate

Response to Comment #2-10: Please see responses to comments #2-1 through #2-9. The comment does not describe the "other" reasons the Draft EIR's identification and analysis of impacts is deemed inadequate.

Comment #2-11: The Draft EIR makes an unfounded assumption that current baseline conditions are not a significant impact because they are not a net increase in greenhouse gas (GHG) emissions.

Response to Comment #2-11: Changes have been made to the Draft EIR. The Draft EIR text has been amended to find that the Project Baseline condition does increase GHG emissions. The text amendments consider the 2010 Project Baseline GHG emissions in terms of the amount of GHG emissions produced per visitor, as the Draft EIR does for the Program Growth Condition. The revised text describes that the 2010 Project Baseline condition results in 0.14 metric tons of carbon dioxide equivalents (MTCO2e) per visitor. This level of GHG emissions is considered a less than significant impact. Please refer to Text Amendments (Section 3.0) for revised text. The Draft EIR's assumptions used to estimate Project Baseline GHG emissions are correct and are based on OSV Program activity levels described in the Draft EIR Project Description.

Comment #2-12: The Draft EIR states baseline levels of direct GHG emissions are not significant yet admits on Page 4-32 that indirect GHG emissions are cumulatively considerable.

Response to Comment #2-12: As a point of clarification, the Draft EIR does not state on Page 4-32 that indirect GHG emissions are cumulatively considerable. The use of "cumulatively" at the beginning of the second sentence under the indirect emissions analysis of OSV use and passenger vehicle travel on page 4-32 refers to the sum of all indirect GHG emissions and is not intended to refer to a cumulative impact analysis, which occurs in Section 4.3.4.3 of the Draft EIR. As identified in Section 4.3.4.3 the project's cumulative GHG emissions levels would be less than significant.

Comment #2-13: The Draft EIR inadequately analyzes "baseline" conditions.

Response to Comment #2-13: See response to Comment #2-1 for discussion of Draft EIR baseline conditions. The correct baseline is the conditions that occur in the Project Area prior to the start of the 10-year program. GHG emissions associated with the OSV Program have been calculated and assessed as impacts of the OSV Program and are not dismissed as baseline conditions. Text Amendments (Section 3.0) are provided to clarify the separation of project emissions from baseline conditions. The Draft EIR concludes that GHG emissions are not significant. The comment does not present any evidence to substantiate the claim that these emissions are significant.

Comment #2-14: Substantial guidance on determining the significance of greenhouse gas emissions is available, including the California Air Pollution Control Officer's Association (CAPCOA) January 2008 white paper entitled *CEQA and Climate Change: Evaluating and Addressing Greenhouse Gas Emissions from Project Subject to CEQA.*

Response to Comment #2-14: The CAPCOA white paper is intended as a resource, not a guidance document, for lead agencies to use when addressing GHG emissions under CEQA. As described in Draft EIR Section 4.3.1.3, the OHMVR Division assessed the significance of the project's GHG emissions using the criteria contained in Appendix G to the CEQA Guidelines. Draft EIR Section 4.1.4.4 provides background on the development of these GHG criteria, which were required by Senate Bill 97.

The reference to *Communities for a Better Env't v. City of Richmond*, 184 Cal.App.4th 70 (2010), appears misplaced. In that case, the lead agency and project proponent unsuccessfully contended the existence of valid permits to operate industrial equipment used in the project at particular levels established an exception to the general rule that existing physical conditions serve as the baseline for measuring a project's environmental effects. Instead, they maintained the analytical baseline for a project employing existing equipment should be the maximum permitted operating capacity of the equipment, even if the equipment is operating below those levels at the time the environmental analysis is begun. The OSV Program does not attempt to take that position. No permits are at issue, and as discussed in the response to comment #2-13, GHG emissions associated with the OSV Program have been calculated and assessed as impacts of the OSV Program and are not dismissed as baseline conditions.

Comment #2-15: The use of a per capita efficiency-based threshold makes little sense for the project's 10-Year Program Growth analysis and the Draft EIR fails to address the cumulatively considerable GHG emissions that result from the project.

Response to Comment #2-15: The DEIR's 10-Year Program Growth GHG emissions analysis is consistent with Section 15064.4 of the CEQA Guidelines. The Draft EIR discloses (Table 4-17) the increase in direct and indirect GHG emissions that would occur with OSV Program Growth by 2020 and considers (Section 4.3.4.2) the extent of this increase on the existing environmental setting, as well as whether the estimated emissions exceed an applicable threshold of significance (Sections 4.3.1.3 and 4.3.4.2). The Draft EIR also considers (Sections 4.1.4.1 to 4.1.4.4) the extent to which the project complies with regulations adopted to reduce GHG emissions.

Table 4-17 provides an estimate of the increase in direct and indirect GHG emissions that would occur with OSV Program Growth by 2020 (4,951 $MTCO_2e$ per year). The Draft EIR considers these emissions in the context of the estimated seasonal number of visitors (300,000) that would occur under the program growth scenario, producing an estimate of 0.11 $MTCO_2e$ per visitor per year under the program growth condition.

As described in Section 4.3.1.3 and 4.3.4.2 of the Draft EIR, the OHMVR Division has not adopted quantitative standards of significance for GHG emissions or potential global climate change impacts, and there are no local or state adopted quantitative thresholds that apply to the proposed project. While several air districts have set quantitative thresholds, including the South Coast Air Quality Management District (3,000 metric tons of carbon dioxide equivalents [$MTCO_2e$] per year for commercial and residential projects and 10,000 $MTCO_2e$ per year for stationary source projects) and the Bay Area Air Quality Management District (1,100 $MTCO_2e$ per year for residential, commercial, and public land use projects, 10,000 $MTCO_2e$ per year for stationary source projects, and 4.6 $MTCO_2e$ per service population per year), the second and third paragraphs on Page 4-35 of the Draft EIR are clear that none of these regional thresholds apply to the proposed statewide project.

The commenter notes that the use of the BAAQMD's service population threshold of significance threshold "makes little sense" in the context of the Draft EIR analysis, the proposed project is not an "efficient" project in the context in which the BAAQMD developed its threshold, and the use of an efficiency based threshold cannot be applied to the proposed project in conformance with BAAQMD standards. As described in the fourth paragraph on Page 4-35 of the Draft EIR, the proposed project is not a typical, regional land use, commercial or stationary source project. The use of an efficiency based metric is appropriate since the project's GHG emissions are produced by a large number of visitors spread throughout the state. The Draft EIR notes in the last sentence of the Indirect Emissions analysis on Page 4-34 that improvements in technology and fuel efficiency would reduce GHG emissions per OSV use-day from 0.163 MTCO2e per use-day under the baseline scenario to 0.130 MTCO2e per use-day under the program growth scenario. The commenter also notes the Draft EIR fails to address cumulatively considerable GHG emissions that result from the project, however, Section 4.3.4.3 of the Draft EIR addresses cumulative GHG impacts.

Comment #2-16: The OHMVR Division must consider ways to avoid, minimize, or mitigate GHG impacts including an accelerated schedule for shifting from diesel to other cleaner fuels, adopting the "Funding Restricted Riding Areas Only" alternative, and/or limiting funding to those areas which allow only OSVs that emit lower emissions.

Response to Comment #2-16: The proposed project does not result in potentially significant air quality impacts that require mitigation. Draft Section 4.4 acknowledges that alternate fuels for grooming and plowing equipment are not likely to be available in the ten year timeframe of the project, there is no commercially available substitute for diesel fuel in heavy-duty, mobile applications, and biodiesel is not a viable substitute since it can gel at low temperatures. Draft EIR Section 9.5 acknowledges the "Funding Restricted Riding Areas Only" alternative would limit OSV use and associated environmental effects; however, this alternative would not meet all project objectives. Draft EIR Section 9.1.4 found the project alternative that would prohibit two-stroke engines both infeasible and impractical. See response to Comment #2-8 and #4-15.

Comment #2-17: Preparation of a Supplemental EIR

The comments received on the Draft EIR have been reviewed. Responses have been prepared to clarify or amplify the analysis and make corrections where needed. The Draft EIR concludes all impacts associated with the OSV Program are less than significant or can be mitigated to a less than significant level through implementation of specified measures. The information presented in the comments and responses do not change the Draft EIR conclusions.

The comments and response to comments do not meet the criteria specified by CEQA Guidelines (Sections 15162 and 15163) requiring preparation of a Supplemental EIR, as a Supplemental EIR is only prepared once an EIR has been certified. Likewise, comments and response to comments do not meet the criteria specified in the CEQA Guidelines (Section 15088.5) requiring recirculation of an EIR. No significant new information has been added to the EIR. Specifically, no new significant environmental impact would result from the project or from a new mitigation measure proposed to be implemented. There is no substantial increase in the severity of an environmental impact that would result unless mitigation measures are adopted. There is no feasible project alternative or mitigation measure considerably different from others previously analyzed that would clearly lessen the environmental impacts of the project. All information provided in this Final EIR merely clarifies, amplifies, or makes insignificant modifications to an otherwise adequate EIR. Therefore, recirculation of the EIR is not required.

Comment Letter #3. Recreation Outdoors Coalition

Comment #3-1: Benefits of OSV Program

Response to Comment #3-1: Comment acknowledged. The comment notes the benefits of the OSV Program to non-motorized users. No specific comments were made on the environmental analysis and therefore no further response is necessary.

Comment #3-2: 10-year program period

Response to Comment #3-2: Comment acknowledged. The comment concurs with proposed 10-year planning horizon of the OSV Program. No specific comments were made on the environmental analysis and therefore no further response is necessary.

Comment #3-3: Future OSV Program opportunities

Response to Comment #3-3: Comment acknowledged. The comment notes that future OSV growth needs increased opportunities, and well-planned trailheads keep riders in appropriate locations and not in areas such as wilderness areas and private lands. Potential areas for OSV Program growth are identified in the Draft EIR Project Description (Section 2.7.1). Although these are identified as potential areas, they are not specifically proposed. Any proposal to expand the OSV Program to new locations would be subject to further environmental review. While the Draft EIR uses an historical average annual growth rate of 4% to project possible growth in OSV use over the 10-year planning period, it should be noted annual growth rates are declining and the need for increased opportunities to meet growth may not be realized. See Attachment B and response to Comment #3-9.

Comment #3-4: OSV growth

Response to Comment #3-4: The ratio of groomed miles to the number of OSVs may not be a particularly useful indicator of the special area needed to adequately provide for OSV recreation. OSV recreation is not limited to the groomed trail system and substantial amount of off-trail riding occurs at the trail sites (Draft EIR, Table 2-9). If projected growth is realized and the OSV Program does not expand existing trail systems or develop new trail systems at new locations, it could lead to more crowded conditions at existing sites which could lead to safety issues. This is discussed in the Draft EIR Recreation chapter (Section 8.3.3.4). Mitigation Measures REC-1 and REC-2 are identified to address potential public safety concerns associated with OSV growth. With these measures in place, potential safety impacts would be reduced to less than significant levels.

Comment #3-5: Project alternatives

Response to Comment #3-5: Comment acknowledged. The comment concurs with rejection of alternatives described in Draft EIR. No further response is necessary.

Comment #3-6: Potential new OSV sites

Response to Comment #3-6: Comment acknowledged. As stated in response to Comment #3-3, no specific plans for expansion are proposed at this time. Safety and management of any proposed new site would be considered during the public planning process and environmental review if and when an expansion site is actually proposed.

Comment #3-7: New trailheads

Response to Comment #3-7: Comment acknowledged. The comment notes the benefits of advanced planning for expansion of the OSV Program. No specific comments were made on the environmental analysis and therefore no further response is necessary.

Comment #3-8: Corrections

Response to Comment #3-8: Comment acknowledged. Specific responses to request for information and noted corrections are presented in response to Comments #3-9 through #3-15.

Comment #3-9: OSV annual growth rate data

Response to Comment #3-9: A chart of annual OSV registrations is presented in Attachment B. The chart shows OSV registrations peaked in 2008 and have since declined. The chart also shows the annual rate of increase has slowed over the last decade. Given this trend, the 4% average annual growth rate used in the Draft EIR is considered conservative.

Comment #3-10: Table 2-6, plow service at Morgan Summit

Response to Comment #3-10: The Lassen National Forest has an inter-agency agreement with Lassen Volcanic National Park in plowing the snowmobile trailhead at Morgan Summit. Caltrans occasionally plows but the official agreement is with the National Park Service. Table 2-6 is corrected accordingly. Please see Text Amendments (Section 3.0).

Comment #3-11: Table 3-2, Lassen Volcanic National Park as Special Interest Area for Morgan Summit

Response to Comment #3-11: Lassen National Forest confirms wilderness areas and the Lassen Volcanic National Park are not accessed from Morgan Summit. Table 3-2 is corrected accordingly. See Text Amendments (Section 3.0).

Comment #3-12: OSV intrusion into Lassen Volcanic National Park

Response to Comment #3-12: Lassen National Forest confirms wilderness areas and the Lassen Volcanic National Park are not accessed from Morgan Summit. Most of the Lassen Volcanic National Park trespasses occur through the Swain Mountain or Bogard trailheads. Trespasses on the Caribou Wilderness occur through the Chester-Almanor, Swain Mountain, or Bogard trailheads. Draft EIR text in Section 3.3.2.2 is corrected accordingly. See Text Amendments (Section 3.0).

The comment states that the public accesses Lassen Volcanic National Park on the south side across Mill Creek. According to Lassen National Forest, this area is private property. The USFS does not have any record of the public accessing the park from this direction. Most of the reported cases of trespass occur into the Caribou Wilderness and into Lassen Volcanic National Park through the Bogard, Swain, and Chester Trailheads.

In the past, some intrusions into Lassen Volcanic National Park have occurred on the west side through Brokeoff Meadows. Sometimes USFS law enforcement officers are asked to assist the National Park Service. Most of the time, the park handles its own intrusions.

Comment #3-13: Table 3-3, OSV intrusion into Lassen Volcanic National Park

Response to Comment #3-13: Comment acknowledged. Text in Table 3-3 is corrected accordingly. See Text Amendments (Section 3.0). Also see response to Comment #3-12.

Comment #3-14: Access to Caribou Wilderness

Response to Comment #314: Comment acknowledged. Text in Table 3-3 is corrected accordingly. See Text Amendments (Section 3.0). Also see response to Comment #3-12.

Comment #3-15: Table 8-3, Morgan Summit parking overflow

Response to Comment #3-15: Table 8-3 is corrected to reflect parking overflow conditions occasionally occur at Morgan Summit. Please see Text Amendments (Section 3.0). Expansion of the Morgan Summit trailhead parking capacity would be a capital improvement project undertaken by the Lassen National Forest apart from the OSV Program. As discussed in the Draft EIR Recreation chapter, many of the OSV Program trailheads lack capacity to accommodate full demand for parking. National forests may consider numerous factors when evaluating whether to expand trailhead parking such as physical constraints, capacity of the recreation area, and funding allocation. The USFS and OHMVR Division have the ability to work collaboratively on development of trailhead parking in the future. In regards to the Draft EIR conclusions of trailhead parking shortages, it was determined parking shortages in themselves are not creating an environmental impact or a public safety impact.

Comment #3-16: New OSV use at Lake Davis

Response to Comment #3-16: Comment acknowledged. The comment notes community efforts to provide trailhead and grooming services for OSV recreation at Lake Davis. No specific comments were made on the environmental analysis and therefore no further response is necessary.

Comment Letter #4. Snowlands Network

Comment #4-1: Project impact on shaping winter recreation opportunity in California

Response to Comment #4-1: The OSV Program creates winter recreational opportunities in California that have resulted in increased visitor use to national forests in the Project Area. The OSV Program trailheads and groomed trail systems are predominately used for motorized recreation, although non-motorized recreation uses such as snowshoeing and cross-country skiing also occur at the project locations. As discussed in the responses to this comment letter below, the OSV Program is not the only source of winter recreation opportunities in California. It is not the purpose of the EIR or OSV Program to assess or meet the demand for all winter recreation opportunities throughout California national forests.

The Draft EIR addresses impacts on the natural environment, including wildlife, water quality, air quality, and vegetation and concludes that all impacts can be reduced to a less-than-significant level. The comment does not provide any information to support its claim that these impacts have not been adequately addressed or identify additional mitigation measures to further reduce these environmental effects.

Comment #4-2: USFS not adequately addressing user conflicts and reduced non-motorized recreation caused by OSV Program

Response to Comment #4-2: The comment is a general accusation against the USFS without specific references, citations to studies, or other verifiable information. The USFS is responsive to use conflicts between motorized and non-motorized groups. As discussed in the Draft EIR Land Use and Recreation chapters, the USFS law enforcement officers and forest protection officers provide routine patrols along the OSV trail routes. The USFS and the OHMVR Division have worked together in the past to resolve site specific conflict issues that have arisen such as the need for increased monitoring and signage at wilderness boundaries or segregation of motorized and non-motorized uses to address safety issues such as the newly created Round Valley non-motorized snowplay area on Stanislaus National Forest, which will open in 2011.

The USFS encourages reporting of specific incidents or conditions occurring on the national forests which need to be addressed. The USFS has law enforcement and forest protection officers that can be dispatched to any location where individual problems are observed. Additionally, complaints can be filed with the ranger district office to alert them of incidents or conditions on the forest that need to be addressed. In preparation of the Draft EIR, each national forest was contacted through a data request and follow-up phone calls to determine the frequency and severity of conflicts occurring between user groups in the OSV Program recreation area. Based on these discussions, it was determined known conflicts are minimal. No new conflict areas or concerns have been brought to the attention of the USFS and in expressing concern about conflict, Comment #4-2 does not present evidence the USFS is unresponsive or provide detail of specific conflicts occurring on the forests that need to be further addressed by the USFS.

The groomed trails and trailhead access provided by the OSV Program is primarily for OSV use although non-motorized users benefit from recreation opportunity and access provided by the program. The OSV Program does not reduce recreation opportunities for clean and quiet non-motorized recreation experiences on national forests. OSV use is established as a permissible winter recreation activity throughout the each forest by its adopted Land Resource Management Plans (LRMP). The OSV Program funds activities to support OSV recreation, which is already consistent with LRMP goals and objectives. If grooming and trailhead plowing were not provided, recreation opportunities for both OSV and non-motorized groups would be reduced. The OSV Program described in the Draft EIR Project Description has occurred for many years and the proposed project represents a continuation of funding of this existing program. The project does not propose an expansion of operations that would displace or reduce non-motorized recreation. Future growth of the program through expansion to new locations would be subject to subsequent environmental review.

Comment #4-3: Use of OSV Program funds for dedicated non-motorized trailheads requested

Response to Comment #4-3: As stated in Draft EIR Section 2.9.1, the OSV Program is funded by the OHV Trust Fund through the 2002 BCP which appropriates funds for grooming, plowing, and maintenance activities in support of motorized winter recreation. OSV Program funds cannot be appropriated exclusively for non-motorized recreation. The issue of increasing recreation opportunities reserved for human-powered winter recreation is a land management issue for the individual national forests which govern activities on the forest and is outside the scope of the OSV Program and this EIR. The contribution of winter recreation (both motorized and non-motorized) to the economies of local communities is acknowledged, however, the economic effects of the OSV Program is not a required discussion under CEQA and therefore not considered in the EIR.

Comment #4-4: Growth in non-motorized recreation contributes to economies

Response to Comment #4-4: Comment acknowledged. Both motorized and non-motorized winter recreation contribute to local economies. CEQA does not require an assessment of the economic merits of a project unless the economic impact directly contributes toward a significant environmental effect. It should be noted the reference study is specific to the Gallatin National Forest, which is located in the northern Rocky Mountains of Montana. While the study documents the popularity of skiing in the Gallatin National Forest, the commenter does not explain how the Gallatin study applies to the 11 California national forests participating in the OSV Program. As shown in the NVUM data presented in Draft EIR Table 8-1, each national forest has a different ratio of motorized and non-motorized use, and therefore the economic contribution of each use varies with the location.

Comment #4-5: Adjustment of OSV Program to balance motorized and non-motorized recreation requested

Response to Comment #4-5: Opportunities for non-motorized winter recreation in California occur in state parks, national forests, national parks, national monuments, and on privately operated facilities. CDPR facilitates non-motorized winter recreation on national forests through both the Sno-Park Program and OSV Program. Roughly half of the 19 sno-parks in the state are reserved for non-motorized uses (Attachment A). See also response to Comment #4-12, #4-14, #4-39, and #4-40.

The USFS is the land manager of national forests and is the agency with jurisdictional authority over how uses on the forest are allocated. Both of motorized and non-motorized winter recreation uses are established as consistent with individual forest plans. The USFS partners with the OHMVR Division through the OSV Program for the purpose of providing winter trailheads and groomed trail access on the national forests. While the OSV Program is primarily provided to serve the OHV community, the increased trailhead access and groomed trails on the national forest also benefits the non-motorized community which is consistent with the goals and objectives of the USFS to accommodate multiple uses on national uses. It is not the role of the OHMVR Division to direct USFS management of its forests or to rectify a perceived imbalance of motorized and non-motorized recreation uses.

Comment #4-6: Snowmobiles are a high impact recreational use

Response to Comment #4-6: Dividing recreation into low and high impacts is one way to describe the characteristics of recreation. However it is a subjective generalization. The OHMVR Division has prepared an EIR to evaluate the potential environmental impacts and recreational conflicts associated with the OSV Program. Potential impacts to wildlife, air quality, water quality, and vegetation are evaluated in the EIR. The advancement of snowmobile capabilities from 20 years ago is acknowledged. It is the current capabilities of snowmobiles that are assumed in the analysis of the EIR. The EIR has concluded all impacts associated with the OSV Program are less than significant or can be reduced to a less than significant level through implementation of specified mitigation measures. The comment does not provide detail of how the EIR understates the impacts of snowmobile use associated with the OSV Program so a more specific response to this comment cannot be provided.

Comment #4-7: Multiple use calls for balancing motorized and human powered recreation opportunities.

Response to Comment #4-7: As discussed in response to Comment #4-2 above, recreational uses on each national forest are established by the forest LRMP. The OSV Program does not establish the use but does fund current OSV activity which is already consistent with LRPM goals and objectives. Whether individual forests need to close areas to OSV use, as suggested in the comment, in order to address a non-motorized recreational need is a land management decision under the discretion of each forest. A forest decision to permanently close an area to OSV use would require environmental review under the National Environmental Policy Act (NEPA) and public involvement. This is a national forest land management issue which is outside the scope of this EIR.

Comment #4-8: Trailheads monopolized by snowmobiles

Response to Comment #4-8: The OSV Program trailheads are not the only point of access on national forests. Other winter trailheads on national forests are provided directly by the individual national forests (e.g., Mammoth and June Lakes areas on Inyo National Forest), by the CDPR through the Sno-Park Program, and by individual counties plowing pullout parking areas on county roads.

The comment notes OSV Program trailheads are dominated by snowmobiles. This comment is certainly consistent with results of the 2009 OSV Winter Trailhead Survey (Draft EIR Appendix A, Table 19). At all the trailheads surveyed, snowmobile use was the primary visitor activity (85% to 100% participating) except at the Iron Mountain trailhead on Eldorado National Forest (57% participating). The high presence of OSV use at these trailheads is to be expected given that the trailheads and groomed trails are funded by the OHV community (through the OHV Trust Fund).

The commenter is correct that the number of groomed trails for motorized recreation outnumber the number of groomed trails dedicated for non-motorized recreation. Motorized recreation requires a larger trail system to provide an adequate range of travel. Human powered recreation has a smaller range and therefore a lower requirement for groomed trail mileage. Non-motorized recreationists can use the groomed trail system funded by the OSV Program. Areas reserved for non-motorized recreation are also provided on some national forests (see response to Comment # 4-14). There are also opportunities for non-motorized recreation throughout California in state parks, national parks, and national monuments where motorized recreation is prohibited.

The USFS does not have funding specifically appropriated for funding winter recreation whether for non-motorized or motorized uses. Likewise, the State of California does not have funding available to create new winter recreation opportunities exclusively for non-motorized recreation. The OHV community has established a funding source (OHV Trust Fund) administered by the State to provide for OSV recreation. The non-motorized recreation community does not have a similar funding program which facilitates recreation areas reserved for non-motorized use. Also see response to Comment #4-12.

Comment #4-9: Undesirability of motorized recreation near non-motorized users; artificial repression of non-motorized recreation

Response to Comment #4-9: The Draft EIR recognizes and analyzes the impact of OSV use on non-motorized recreationists (Draft EIR, Section 8.3.2.3).

As noted in the comment, the predominant use at the OSV Program trailheads is motorized recreation. This can account for the minimal number of conflicts between non-motorized and motorized user groups at these locations. Contrary to the comment’s assertions, the non-motorized users choosing to recreate at OSV Program trailheads are not there because of lack of opportunity elsewhere. There are other options. See response to Comments #4-12 and #4-14.

The perceived lack of areas protected for quiet recreation on national forests is an issue of forest land management which is outside the scope of the OSV Program EIR. It is the mandate of the OHMVR Division to facilitate and manage motorized vehicle recreation in the State of California. The OSV Program administered by the State is consistent with this objective and assists the USFS by facilitating winter recreation access to the national forests.

There is no evidence that the provision for OSV recreation through the OSV Program does not result in the artificial repression of skiing and snowshoeing. As noted in response to Comments #4-12 and #4-14, there are opportunities for quiet recreation apart from OSV Program locations.

Comment #4-10: Growth in OSV Program exacerbates imbalance of motorized and non-motorized recreation.

Response to Comment #4-10: The OHMVR Division acknowledges the possibility of growth in OSV recreation and has identified potential locations where OSV Program operations could be expanded. However, no plans for expansion have been proposed or are being planned at this time. The potential for new OSV Program trailheads and groomed trail systems to impact non-motorized recreation would be evaluated at the time a new location is actually proposed. Such development proposals would be subject to a public planning process and environmental review under both CEQA (for state action) and NEPA (for federal action).

Comment #4-11: Human-powered sports serve government policies, have benefits

Response to Comment #4-11: The comment makes a statement on the benefits of non-motorized recreation. No comment is presented on the EIR and therefore no further response is required.

Comment #4-12: Growth in human-powered recreation would occur with provision of a fair share of recreational opportunities. Trailheads are monopolized by snowmobiles.

Response to Comment #4-12: The USFS does not have specific appropriated funding for groomed trails or winter trailhead access on the national forest. The State of California partners with the USFS to fund motorized and non-motorized winter recreation access on national forests through the OSV Program and through the Sno-Park Program.

The OSV Program exists for the primary purpose of supporting motorized winter recreation; it is funded by OHV fees and taxes paid into the OHV Trust Fund (Draft EIR, Section 2.9.1). The trailheads and groomed trails "monopolized by snowmobiles" are both paid for and predominately used by OSV riders; however, they are available to non-motorized use as well. Without OSV Program funding, these trailheads would not be plowed and would not be available for easy access for winter recreation.

The Sno-Park Program provides access to national forests for general winter recreation at 19 locations. Information on the individual sno-parks is presented in Attachment A to this Final EIR document. Sno-parks primarily provide non-motorized recreation opportunities although snowmobile use occurs at 9 sno-parks trailheads, 7 of which are combined with the OSV Program. The two sno-parks which allow snowmobile use which are not part of the OSV Program include Hope Valley on the Humboldt-Toiyabe National Forest and Blackwood Canyon on the Lake Tahoe Basin Management Unit. It should be noted that unlike the OSV Program, the Sno-Park Program is not self-funded; sno-park permit fees collected at the trailheads do not cover the cost of the Sno-Park Program. The sno-parks are subsidized by funds from the OSV Program by combining trailheads with sno-parks at 7 locations as referenced in the Draft EIR.

Forest land is open to both types of uses and through the OSV Program, the OSV community pays for access and trails which can be used by both groups. The State of California provides additional opportunity on the forests exclusively for non-motorized recreation through the Sno-Park Program.

Comment #4-13: NVUM data shows popularity of skiers and snowshoers over snowmobilers

Response to Comment #4-13: The NVUM data presented in the Draft EIR (Table 8-1) is presented for the purpose of characterizing winter recreation use levels occurring in the national forests as background setting information. The visitor data is not site specific to OSV Program trailheads and therefore was not used to identify visitor use levels or recreational use type at the OSV Program sites. Therefore, if the NVUM data underestimates skiing and snowshoeing, it would not affect the analysis contained in the Draft EIR or the conclusions of the Draft EIR.

Comment #4-14: Wilderness areas inaccessible to non-motorized use

Response to Comment #4-14: The comment does not address a significant Project impact. Regardless, the OHMVR Division acknowledges that wilderness areas can be difficult to access in winter due to their remote location with trailheads that are often not plowed during winter. However, the OSV Program trailheads do provide immediate access to some wilderness areas such as Bucks Lake Wilderness (Plumas National Forest) and Kaiser Wilderness (Sierra National Forest), which are closed to OSV use (see Draft EIR Figures 2A through 12D for proximity of wilderness areas to OSV Program trailheads). Wilderness areas are not the only places closed to motorized use. As noted in response to Comment #4-12, the State of California maintains 19 sno-parks on national forests, 10 of which do not allow snowmobiles. Separate from these sno-parks, many forests have designated cross-country ski areas which are closed to motor vehicle use such as McGowen Lake (Lassen NF), Steephollow and Kyburz (Tahoe NF), Coyote (Sierra NF), Obsidian Dome (Inyo NF). Additionally, state parks, national parks, national monuments, and privately operated facilities in California are also closed to winter motorized use and are available for non-motorized winter recreation.

Comment #4-15: Project Alternatives

Response to Comment #4-15: The Draft EIR considered a wide range of project alternatives. After consideration, many of these alternatives were rejected (see Draft EIR, Section 9.1.4) for being infeasible, not meeting project objectives, or not reducing significant environmental impacts.

Requiring the use of newer four-stroke engines was considered and rejected as an alternative (Draft EIR, Section 9.1.4). The environmental benefits of four-stroke engines are acknowledged in this alternative; however, because national forest lands are open and ungated, there is no way for the USFS to practically enforce a prohibition of two-stroke engines on the project trail systems. While the USFS is responsible for enforcing rules set by CARB and California EPA and would take action to enforce vehicle codes if two-stroke engines were banned in the state in the future, this action is very different than enforcing a ban limited to OSV Program trailheads on the forest on vehicles that are otherwise legal in California and in other locations on these same forests.

The Funding of Restricted Riding Areas Only was evaluated as a project alternative and identified as the environmentally superior alternative (Draft EIR, Section 9.5). This alternative would eliminate grooming on 24 of the 26 trail systems in the OSV Program. OSV use could still continue in the 24 locations no longer groomed due to forest LRMP directive which allows OSV use on open forest land; however, the OSV use levels at these locations would be reduced. Groomed trails would only be provided on the Giant Sequoia National Monument (Quaking Aspen/Sugarloaf and Big Meadow/Quail Flat trail systems) where OSV use occurs only on National Forest Transportation System Roads and no-off trail riding is allowed. This alternative does not meet the project objective which is to facilitate and manage OSV recreation throughout the California. The proposed project best facilitates the project objective by providing trailhead access and groomed trails, which offer a stable snow surface for riders of all skill levels, plus non-motorized recreationists such as skiers and dogsledders. Grooming in the various forest locations also facilitates management of OSV recreation occurring within the forests by creating easier access for law enforcement patrols and search and rescue efforts.

The OHMVR Division conferred with the USFS Regional Office when evaluating project alternatives. The USFS cannot close the project areas to off-trail riding in exchange for continued receipt of grooming funds. As described in Draft EIR Section 9.1.3, OSV use is established as a permitted use on forest lands by the governing LRMP. Closure of off-trail riding areas would require a change in each forest LRMP; each national forest would have to amend its LRMP through a public planning process in order to close areas of the forest to OSV use. Without a demonstrated substantial impairment to natural resources or serious recreation use conflicts caused by OSV use, there is no purpose or need to prohibit off-trail riding; as such, individual national forests would not consider changing their forest LRMP to restrict OSV use.

Comment #4-16: Project Alternatives

Response to Comment #4-16: The OHMVR Division and USFS disagree with the premise of the comment that the OSV Program creates a de facto winter recreation plan on national forests. Winter recreation on the forests, both motorized and non-motorized, are established by the LRMPs. These plans were adopted on each forest through a public planning process involving an environmental impact statement (EIS) and a Record of Decision. The OSV Program facilitates motorized recreation on forest lands where the use is already permitted.

As noted, the USFS has a duty to manage OSV recreation in a manner that minimizes impacts to water, wildlife, vegetation, and other resources as well as to other recreational uses. The environmental analysis presented in the Draft EIR concludes impacts to natural resources from OSV use can be managed to less than significant levels. The Draft EIR also concludes recreational use conflicts are adequately managed and are not substantial. Expansion of the OSV Program has not been proposed; any expansion to new locations would be subject to subsequent public planning process and environmental review.

Comment #4-17: Area of controversy

Response to Comment #4-17: At the time the Draft EIR was published, the primary concern raised in public comment, which came during public review of the 2008 Initial Study/Negative Declaration and 2009 Initial Study/Negative Declaration, was the impact of snowmobile use on plants and wildlife throughout the forest, trespass into restricted areas such as protected wilderness, adequacy of law enforcement, detrimental effects on non-motorized recreationists, and general effects on noise, air quality, and water quality. No environmental concerns or areas of controversy were identified during the public review of the NOP for the OSV Program EIR or during the public scoping meetings prior to preparation of the Draft EIR.

As noted, the primary issue of concern raised in the Snowlands Network comment letter on the Draft EIR is the effect of the OSV Program on non-motorized recreation in California. The commenter asserts, “The grooming program actively promotes the growth of snow by facilitating growth of snowmobiling, and unfairly restrains the growth of quiet winter recreation such as skiing and snowshoeing.” This issue is addressed in response to Comments #4-7, #4-8, #4-10, and #4-12.

Comment #4-18: Baseline conditions

Response to Comment #4-18: See response to Comments #2-1 and #2-11. The commenter has offered no information about why the baseline is wrong but simply states a conclusion.

Comment #4-19: Growth in winter recreation

Response to Comment #4-19: It was not the intent or within the scope of the EIR to assess non-motorized winter recreation use levels and the adequacy of existing opportunities to meet that demand. The purpose of the EIR is to assess the environmental effects of maintaining OSV Program trailheads and groomed trail systems that primarily serve motorized use. Seven of the OSV Program trailheads share parking lots with sno-parks. Thus, for the purposes of addressing the demand on OSV Program parking facilities over the 10-year program period, the number of sno-park permits issued at these locations were used to assess demand by non-motorized use. As stated in the Draft EIR Project Description, Section 2.7, there has been little growth in the issuance of sno-park permits indicating increases in the demand for parking at the combined OSV Program/Sno-Park Program trailheads would primarily come from growth in OSV recreation.

The EIR does not make assumptions about the popularity of skiing and snowshoing or the level of these uses occurring throughout the forests or throughout the State. As stated above, it is not the purpose of the EIR to evaluate demand for non-motorized recreation opportunities.

The comment makes an erroneous statement that snowmobiling on national forests is free. As stated in response to Comments #4-4, #4-8, #4-12, #4-30, #4-39, and #4-40, the OSV Program is paid for by the OHV Trust Fund which receives its funds from the OHV community through OHV registration fees, State Vehicle Recreation Area fees, and gas tax (see Draft EIR, Section 2.9.1). Hence, the winter access and groomed trails created by the OSV Program are largely paid for by OSV users. The only fees paid by non-motorized visitors to the national forests are the $5 sno-park permits if they choose to recreate at a sno-park trailhead.

As stated in response to Comment #4-13, the NVUM data identified in the Draft EIR (Table 8-1) is presented for background purposes only. The data is not used to assess environmental impacts of the OSV Program and therefore whether it accurately reflects growth in non-motorized sports does not affect the EIR analysis or its conclusions.

The number of snowmobile registrations in California declined in 2009 and 2010 (see Attachment B). The Draft EIR assumed a 4% average annual growth rate as a conservative estimate in order to evaluate the maximum likely environmental effects from OSV use which could likely occur during the 10-year program period. If snowmobile use continues to decline, then the potential for environmental effects of the OSV Program would be less than those described in the Draft EIR.

The decline in sno-park permit purchases is an indication that demand for non-motorized recreation at these locations has declined. It does not mean non-motorized sports are in decline at all locations throughout the State. As stated previously, the Draft EIR does not make an assessment of the demand for non-motorized winter recreation areas; whether sno-parks are meeting the demand for non-motorized recreation is outside the scope and purpose of this EIR.

Comment #4-20: Intrusion into closed areas and enforcement

Response to Comment #4-20: The OHMVR Division disagrees with several assertions in this comment. After consulting the USFS staff on each national forest, the OHMVR Division concluded the incidents of OSV trespass into closed areas were effectively managed by the national forests to prevent chronic incursions (Draft EIR, Section 3.3.2.2). The OHMVR Division has no documented evidence suggesting the severity of the trespass incidents is underestimated by the USFS. Although the comment states that Snowlands Network and Winter Wildlands Allliance receive many complaints about illegal snowmobile use, the comment does not provide any specific detail about the incidents not being actively addressed by the USFS, such as when and where they are occurring, the frequency of occurrence, and the extent of the trespass. Without providing further information, the claims of frequent OSV trespass cannot be substantiated or corrected.

The Draft EIR concludes existing trespass levels associated with the OSV Program are not significant based on the frequency, nature, magnitude, and severity but acknowledges growth in OSV use could result in increased incidents of trespass (Draft EIR, Section 3.3.2.2). As the land use management agency with enforcement jurisdiction, it is appropriate to rely on the USFS to provide the law enforcement action necessary to mitigate OSV trespass. Measure LU-1 requires increased enforcement action in response to specific concerns to be jointly provided by the USFS and OHMVR Division. As noted in response to comment #1-1 from Lassen National Forest, the OHMVR Division recognizes there may be instances where supplemental state funding of USFS law enforcement efforts may be warranted; this would be evaluated by the OHMVR Division on a case-by-case basis.

The Draft EIR recognizes the potential for OSV use to diminish the quality of recreation experienced by non-motorized users (Draft EIR, Section 8.3.2.3). That illegal OSV use in wilderness areas impairs enjoyment of the wilderness by non-motorized users is acknowledged. As stated in the Draft EIR, addressing OSV trespass is a high priority for the OHMVR Division and therefore Measure LU-1 is identified to ensure trespass continues to be properly addressed.

As stated above, it is entirely appropriate to rely on the USFS to provide law enforcement on the forest land it manages. CEQA assumes Lead Agencies can rely on another public agency to use their regulatory powers to mitigate project effects (CEQA Guidelines Section 15091. Measure LU-1 requires that the USFS continue monitoring and demonstrate to the OHMVR Division that monitoring is occurring by submitting patrol logs of the Project Area. The OHMVR Division would review the patrol logs to ensure monitoring is occurring and work with the USFS to determine when additional law enforcement actions are necessary. This level of administrative oversight by the OHMVR Division would ensure trespass incidents are being monitored and addressed when they occur. With the implementation of monitoring and Management Actions prescribed in Measure LU-1, the impact of trespass would remain less than significant.

It is recognized OSV trespass can occur despite constant monitoring. All wilderness boundaries are not under constant surveillance. Therefore, it is possible for trespass to occur without the individuals being caught. Those who are caught are cited. The criteria used to evaluate the significance of the trespass impact is not whether an incident occurs, but whether it is frequent, purposeful, severe, and damaging (Draft EIR, Section 3.3.1). After careful evaluation of the information provided by the national forests, the Draft EIR concludes the trespass impact related to the OSV Program is less than significant.

Comment #4-21: OSV emissions emit more pollution than passenger vehicles

Response to Comment #4-21: Comment noted. Tables 4-11, 4-13, and 4-14 of the Draft EIR provide estimates of the emissions generated by the OSV use and visitor vehicle travel and the Draft EIR concludes these emissions would result in less than significant impacts.

Comment #4-22: Comparison of restrictions on snowmobile emissions to restrictions on passenger vehicle car emissions

Response to Comment #4-22: In general, section 4.1.3 of the Draft EIR discusses the regulations that govern mobile sources of emissions, including off-road diesel vehicles, on-road diesel vehicles, and over-snow vehicles, and on-highway motor vehicles. The Draft EIR evaluates the OSV emissions as part of the project's indirect emissions analysis and concludes this impact is less than significant.

Comment #4-23: Disclosure of assumptions regarding the composition of future snowmobile fleets used in the air quality analysis and future pollution estimates

Response to Comment #4-23: Table 2-9 of the Draft EIR estimates existing users at OSV Program trail sites are approximately four percent four-stroke engines and 96 percent two-stroke engines OSV. Per Appendix E, Table AQ-10, the Draft EIR assumes future snowmobile fleets would be composed of 20% four-stroke vehicles and 80 % two-stroke vehicles. The increase in fleet-wide four-stroke engines is due to fleet turnover and attrition, and regulations adopted by the EPA in 2002 are also expected to increase use of four-stroke engines.

The commenter notes the EIR must provide estimates of future pollution assuming no changes in fleet composition; however, this is not a likely or realistic scenario that should be analyzed by the EIR. As equipment ages its wears down or becomes obsolete and is replaced with newer equipment, resulting in changes to fleet composition. Fleet evolution is a standard part of all vehicular emissions inventory forecasts.

Comment #4-24: Consideration of OSV air pollution on other users and at trailheads

Response to Comment #4-24: The comment is not clear to whom "other users" refers to; however, the Draft EIR adequately considers the impacts of OSV emissions, as well as direct plowing and grooming and indirect passenger vehicle emissions, on ambient air quality standards and sensitive receptors, including non-motorized recreational users. The Draft EIR analyzes the impacts of baseline conditions on air quality standards and sensitive receptors on Pages 4-22 through 4-24 and concludes baseline conditions would not result in potentially significant air quality impacts. Similarly, the Draft EIR analyzes the impacts of program growth conditions on air quality standards and sensitive receptors on Pages 4-27 and 4-28 and concludes program growth conditions would not result in significant air quality impacts.

OSHA and other workplace standards are occupational exposure standards designed to protected workers from occupational hazards. Employers must comply with all applicable OSHA standards; however, the use of OSHA or other workplace standards is not an appropriate threshold for assessing the significance of potential adverse changes to the environment under CEQA.

Comment #4-25: Consideration of policies to mitigate OSV impacts, including prohibiting older technology

Response to Comment #4-25: The proposed project does not result in potentially significant air quality impacts that require mitigation. Section 9.1.4 of the Draft EIR found the project alternative that would prohibit two-stroke engines both infeasible and impractical because two-stroke engines are legal in California, and banning their use would put the OSV Program and the national forests at odds with state law. Restricting two-stroke engines would have to occur through state legislative mandate which is outside the scope of the project and the authority of the OHMVR Division. Also see response to Comment #2-8 and #4-15

Comment #4-26: USFS environmental analysis of OSV use

Response to Comment #4-26: Winter recreation on forest land is established by the individual forest plans (LRMPs) which were all adopted through a public planning process involving an EIS and a Record of Decision. OSV use on the forest land is permissible in all areas unless specifically designated as closed to that use. Winter trail grooming occurs over an existing road and trail network within the forest which are designated as open to OSV use by the forest plans. Winter trail grooming facilitates OSV use but does not establish the use as a new activity on the forest. Categorical exclusions have been approved for trail grooming activity as an extension of the forest’s operation and maintenance activities. Preparation of an environmental assessment for winter trail maintenance is not necessary.

Comment #4-27: Outdated scientific studies

Response to Comment #4-27: The commenter states the DEIR “makes several statements and determinations that are not rooted in sound science or evidence.” However, the commenter does not provide examples of these statements and determinations, but does refer to a sentence in the DEIR acknowledging the lack of recent studies documenting OSV impacts on wildlife populations. Most, but not all, studies looking specifically looking at OSV impacts on wildlife populations were performed in the 1970s and early 1980s. Several studies were performed more recently for the National Park Service and the Yellowstone National Park winter management plan. The DEIR reviewed all these relevant studies and many are similarly referenced in the commenter’s attached appendix. When discussing wildlife disturbance, all of the arguments presented by the commenter’s appendix are the same as addressed and resolved in DEIR 5.3.2 and Mitigation Measures BIO-1 through 5. Several arguments presented in the commenter’s appendix are irrelevant to the geographic scope of the DEIR. The commenter presents a lengthy discussion of snowmobile impacts to moose, grizzlies, grey wolves, Canadian lynx, white-tailed ptarmigan, and bull trout. None of these species are present in California. The commenter’s discussion for wolverine does not present anything different than that addressed and resolved in DEIR 5.2.7.2 and 5.3.2.1 and Mitigation Measure BIO-2.

Comment #4-28: Soil compaction impact

Response to Comment #4-28: Comment acknowledged. As noted, riding styles of snowmobilers can vary greatly. Jumping and carving done by skilled riders can cause compaction to a greater depth than would occur from flat riding over a groomed surface. Riders engaging in these activities are doing so in low snow or exposed soil conditions where the soil surface would be impacted. Monitoring by USFS has not shown evidence of soil disturbance such as rutting or compaction caused by OSV use (see Draft EIR reference USFS 2009c).

Comment #4-29: Verifiable reporting of mitigation success and automatic suspension of grooming

Response to Comment #4-29: Comment acknowledged. CEQA Guidelines require that a mitigation monitoring and reporting program be adopted to ensure measures needed to reduce significant environmental effects of the project are implemented. Many of the mitigation measures require implementation of protective measures dependent upon the results of monitoring efforts by the USFS. The OHMVR Division is responsible for reviewing the monitoring results and ensuring the USFS is taking appropriate actions based on the results of the monitoring. The OHMVR Division has administrative oversight of the OSV Program and the funding contracts it issues to the USFS. If the national forests do not comply with the mitigation measures attached as conditions to its funding contract with the OHMVR Division, individual contracts can be canceled and state funding of the plowing and grooming activities associated with the OSV Program would be suspended.

Comment #4-30: Impact of OSV noise

Response to Comment #4-30: Snowmobiles do generate noise. As described in the Draft EIR (see page 7-5, OSV Use), noise from snowmobiles are regulated by California Vehicle Code (DVC) to an 82 dBA limit. As shown in Draft EIR Table 7-1, noise from aircraft flyover at 1,000 feet generates is 105 dBA which is much greater than a snowmobile.

Ambient noise levels in open space recreation areas such as national forests are generally quiet with typical noise levels ranging from 35 to 45 dBA Draft EIR, Section 7.2.3). As a result, noise generated by any motorized equipment in the forest is readily audible in the surrounding vicinity. The impact of noise on non-motorized recreationists seeking a quiet experience is acknowledged (see Draft EIR, Section 8.3.2.3).

The fact that a noise source exists does not make the noise generated a significant impact. Noise levels on forest lands are not regulated to an ambient noise standard and OSV use is a permissible use throughout national forests lands unless otherwise restricted. The Draft EIR conclusion that the noise impact of OSV use is less than significant, as clarified by Text Amendments (see Section 3.0), is partially based on the absence of noise standards and the authorization of the use established by the forest LRMPs. However, the conclusion that the noise impact on non-motorized users in the vicinity is less than significant impact is largely based on the quick dispersal of OSV riders away from non-motorized users and the voluntary nature of the non-motorist to recreate in a motorized vehicle area established primarily for motorized vehicle use. As described in response to Comment #4-14, non-motorized recreationists seeking a quiet experience have other options to using a groomed trail system provided by OHV Trust Funds.

Comment #4-31: Actual OSV noise levels

Response to Comment #4-31: As noted in Draft EIR Section 7.1, the CVC standard for OSV noise is 82 dBA. As acknowledged in the recreation conflict discussion (Draft EIR, Section 8.3.2.3), a small percentage of those surveyed modified their equipment which can result in louder engine noise than the 82 dBA standard. Noise levels associated with OSV use varies with the equipment, how it is operated, and environmental conditions such as snow surface compaction, terrain, vegetation, and weather. As such, the noise emitted from an OSV is not constant but will fluctuate with speed, riding style, snow conditions, and distance from the affected noise receptor. These factors influence actual OSV noise levels more than manufacturer specifications. This variability also renders periodic noise sampling from yielding meaningful conclusions that can apply to all OSV Program trail systems or even to those areas sampled with any regularity. It is sufficient to acknowledge that OSV use is distinctly audible on the forest in the immediate vicinity of its use.

Comment #4-32: Winter landscape particularly susceptible to noise

Response to Comment #4-32: As noted in the previous response to Comment #4-31, weather and snow conditions can influence how far sound travels. The Draft EIR does not make specific assumptions on the distance sound travels when assessing the impact of OSV noise. As stated in response to Comment #4-30, the conclusion of a less than significant noise impact is largely based on the quick dispersal of OSV riders away from non-motorized users and the voluntary exposure to OSV noise when choosing to recreate in an area primarily maintained for motorized vehicles. The commenter does not offer any sources as the basis for their opinions and conclusory statements.

Comment #4-33: USFS zoning powers and restriction of OSV use in national forests

Response to Comment #4-33: The Draft EIR does not make an assumption the USFS addresses OSV noise through zoning powers. As stated in Draft EIR Section 7.1, OSV use on national forest lands are subject to state standards implemented through California Vehicle Code and manufacturer restrictions. Individual forest LRMPs do not identify Standards and Guidelines (S&Gs) regulating noise emissions of activities on the forest.

The incorrect statement regarding OSV use restricted to trails has been deleted. Please see Text Amendments (Section 3.0). See response to Comment #4-14 regarding other recreation areas outside of wilderness areas closed to snowmobiles.

Comment #4-34: Significance of noise impact

Response to Comment #4-34: As concluded in the last paragraph of Draft EIR Section 7.3.2.1, and as clarified by the text amendments presented for page 7-6 (see Text Amendments, Section 3.0), the noise impact of the OSV Program at the 2010 operating level is considered less than significant based upon the fact that the motorized and non-motorized uses are dispersed, the non-motorized users are willingly recreating in a motorized vehicle area, and other options are available for those users wanting to recreate where no motorized use is allowed.

Comment #4-35: Recreation conflicts; motorized travel plans

Response to Comment #4-35: Draft EIR Section 8.1.4 identifies the plans of the USFS which govern motor vehicle recreation as regulatory setting for discussing the OSV Program. As discussed under Travel Management, individual national forests throughout California are completing Subpart B of the Travel Management Rule which designates routes for cross-country motor vehicle travel on forest lands. Subpart B addresses summer travel or wheeled vehicle use. It does not address over snow vehicles. Subpart C of the Travel Management Rule, designation of routes for over snow vehicles, is not mandatory. Under 36 C.F.R. 212.81, closure of routes or restriction of OSV use is a discretionary action which may be taken by individual forests if there is impact to natural resources or land use conflicts. At no point does the Draft EIR analysis rely on an assumption that winter recreation conflicts between motorized and non-motorized users are being addressed by USFS travel management plans. The Draft EIR fully addresses the potential conflicts between motorized and non-motorized recreation in Section 8.3.2.3.

Comment #4-36: NVUM data

Response to Comment #4-36: The Draft EIR relies on sno-park permit data to assess the contribution of non-motorized recreationists to OSV Program trailhead parking areas particularly at the seven trailheads where OSV trailhead parking is combined with sno-parks. Based on the decline in purchase of sno-park permits over the last eight years (Draft EIR, Table 2-10), the Draft EIR assumes the number of non-motorized users at the OSV Program trailheads will remain similar to current use levels with no substantial increase (Draft EIR Section 2.7.2.2). This is not a statement on the popularity of non-motorized sports in California or the demand for non-motorized recreation areas.

The comment notes NVUM data presented in Table 8-1 of the Draft EIR understates skiing and snowshoeing. Please see response to Comment #4-13.

Comment #4-37: Limit in areas available to OSV use

Response to Comment #4-37: The Draft EIR acknowledges advancement in technology has allowed snowmobile use to extend its speed, range, and capabilities. However, as noted in the referenced Draft EIR statement, there are physical geographic constraints which restrict OSV use in some areas such as river canyons, excessively steep terrain, thick vegetation (Draft EIR, Section 5.2.2), lack of snow, and poor access. These constraints remain regardless of past technological improvements of the snowmobile.

Comment #4-38: Reliance on 73db noise standard

Response to Comment #4-38: The referenced section of the Draft EIR acknowledges noise affects non-motorized recreationists. The conclusion of a less than significant impact is not based on the 73db noise standard but rather on limited and voluntary exposure to the noise source. See response to Comments #4-30 through #4-34.

Comment #4-39: Bootstrap argument that conflict is irrelevant; false assumption that USFS provides a proportionate amount of areas reserved for and accessible to nonmotorized users.

Response to Comment #4-39: The Draft EIR (Section 8.3.2.3) acknowledges there is a degree of incompatibility between OSVs and non-motorized recreationists seeking a quiet, pristine natural experience. The Draft EIR identifies several OSV use characteristics that can impact the quality of non-motorized recreation including noise, exhaust, safety concern, and tracks. The scope of the Draft EIR is to address the effects of the OSV Program and the subsequent recreation use it facilitates, not OSV use forest-wide and not whether the forest plans make proportionate lands available for non-motorized recreation use. The forest land utilized by the OSV Program has established both motorized and non-motorized winter recreation as permissible uses in the OSV Program Project Area through forest plans (LRMPs). Consistent with the LRMPs, the OSV Program facilitates both winter uses. The OSV Program doesn’t create a new mix of uses or recreation use conflicts which would not otherwise occur.

The USFS does not provide (i.e. fund) groomed winter trails on forest land whether for motorized or non-motorized recreation. As stated in response to comment #4-12, the plowed trailhead access and groomed trails provided on the national forests by the OSV Program is paid for by the OHV Trust Fund for the primary purpose of facilitating winter motorized recreation. Non-motorized recreationists benefit from this provision. Non-motorized users of the trail system should be aware of the potential to encounter the sight or sound of an OSV during their experience on an OSV Program trail. Non-motorized users do not have OSV Program trails as their only option for recreation. Non-motorized recreationists seeking a pristine experience can utilize areas where OSV use is less popular or OSV use is prohibited such as several of the sno-parks (see Attachment A), state and national parks, national monuments, and wildernesses. See also response to Comment #4-14.

Comment #4-40: Increase in trailheads reserved for non-motorized use

Response to Comment #4-40: The Draft EIR concludes use conflicts between non-motorized and motorized winter recreation uses associated with the OSV Program are low and less than significant (Draft EIR, Section 8.3.2.3). As a result, no mitigation is required; the OHMVR

Division does not need to contribute funding to create trailheads reserved for non-motorized recreation to mitigate OSV Program effects.

The OHMVR Division does provide supplemental funding to the Sno-Park Program by sharing 7 trailheads as described in response to Comment #4-12. Ten of the 19 sno-parks do not accommodate snowmobiles and are reserved for non-motorized use (see Attachment A). As stated previously, the OSV Program trailheads and groomed trail systems are paid for by the State through OHV Trust Funds collected from the OHV community. The State does not have similar funds collected from the non-motorized recreation community to support dedicated non-motorized areas. The Sno-Park Program collects sno-park permit parking fees ($5 permits) which are insufficient revenue to fully fund the cost of the Sno-Park Program. The State does not have funds to expand the Sno-Park Program to provide additional areas dedicated to non-motorized use.

It should be noted a new sno-park is being planned on the Stanislaus National Forest using federal grant money (Recreational Trails Program funds from the Federal Highway Administration). The Round Valley Sno-Park will be opened in 2011 and reserved for non-motorized winter recreation use.

Comment #4-41: Restrictions on older technology

Response to Comment #4-41: The Draft EIR recognizes OSV exhaust and noise detract from the clean quiet experience desired by non-motorized recreationists (Draft EIR, Section 8.3.2.3). As discussed in Project Alternatives (Draft EIR, Section 9.1.4) and response to Comment #4-15, restricting the use of 2-stroke engines in the Project Area is impractical and rejected from further consideration. Also see response to Comments #4-23 and #4-25.

Comment #4-42: Additional funds for enforcement

Response to Comment #4-42: The Draft EIR concludes trespass associated with existing OSV use levels that would continue under the OSV Program is being effectively managed by current USFS law enforcement efforts. Growth in OSV use over the 10-year program period could warrant the need for additional law enforcement. Mitigation Measure LU-1 requires additional law enforcement actions be implemented where monitoring shows increased enforcement is needed to address an identified problem. Provision of adequate law enforcement is the responsibility of the USFS. However, as noted in response to Comment #1-1, the OHMVR Division recognizes there may be instances where supplemental state funding may be possible; this would be evaluated by the OHMVR Division on a case-by-case basis.

Comment #4-43: USFS recreation plan needed

Response to Comment #4-43: See response to Comments #4-7 and #4-15.

Comment Letter #5. Elizabeth Norton

Comment #5-1: Request for copy of Draft EIR

Response to Comment #5-1: Comment acknowledged. OHMVR Division sent Ms. Norton a CD of all requested documents. No comment was made on the Draft EIR and no further response is necessary.

Comment Letter #6. Byron Baker

Comment #6-1: Snowcat repair and replacement

Response to Comment #6-1: Comment acknowledged. OHMVR Division contacted Mr. Baker regarding snowcat equipment information. No comment was made on the Draft EIR and no further response is necessary.

Comment Letter #7. Michael E. Evans

Comment #7-1: Addition of Cisco Grove to OSV Program

Response to Comment #7-1: Cisco Grove, located in Tahoe National Forest off Interstate 80 near Soda Springs, offers access to approximately 16 miles of winter trails along Rattlesnake Creek groomed by a private vendor (See Draft EIR Table 8-2). The trail systems groomed by the state-funded OSV Program have been established by the individual national forests. The addition of Cisco Grove to the OSV Program or cutting a new trail to connect the Cisco Grove trail system to the Little Truckee trail system on the Tahoe National Forest is not considered in the OSV Program Draft EIR. Such a change could be proposed at the discretion of the national forest and this decision would be subject to environmental review under both the NEPA and CEQA.

Comment Letter #8. Paul Juhnke

Comment #8-1: Addition of Cisco Grove to OSV Program

Response to Comment #8-1: Comment expresses general support for OSV recreation and grooming at Cisco Grove. See responses to comment from Michael Evans and Bill Harbaugh. No comment was made on the Draft EIR and no further response is necessary.

Comment Letter #9: Bill Harbaugh

Comment #9-1: Addition of Cisco Grove to OSV Program

Response to Comment #9-1: Winter trail grooming at Cisco Grove is provided by a private vendor on the Tahoe National Forest and is not included in the state-funded OSV Program. The OHMVR Division works cooperatively with each national forest to fund selected winter trail systems. Any changes to the OSV Program, such as the redirection of funds from China Wall to Cisco Grove, would have to be requested by the individual national forest. Such a change would be subject to environmental review under both NEPA and CEQA.

Comment Letter #10. Steve Moulis

Comment #10-1: Addition of Cisco Grove to OSV Program

Response to Comment #10-1: Comment expresses general support for OSV recreation and Cisco Grove. See responses to comment from Michael Evans and Bill Harbaugh. No comment was made on the Draft EIR and no further response is necessary.

Comment Letter #11. Steve Rounds

Comment #11-1: General support for OSV recreation

Response to Comment #11-1: Comment expresses general support for OSV recreation. No comment was made on the Draft EIR and no further response is necessary.

Comment Letter #12. Jeff Erdoes

Comment #12-1: Aesthetics improperly dismissed

Response to Comment #12-1: It is recognized there is visual beauty associated with undisturbed snowscape. Non-motorized recreationists as well as OSV riders seek out areas where snow is untrammeled. Tracks frozen in the snow can be made by both motorized and non-motorized recreation and can persist for days or weeks until covered by a fresh blanket of snow. The disturbance of the snowscape is not considered significant given that it occurs in an active recreation area and is temporary in nature. It does not permanently alter the underlying landform.

OSV use is allowed throughout national forests unless otherwise specified. While the OSV Program has the effect of increasing OSV use in the Project Area, the use already exists by forest plan and would continue at some level without the OSV Program. Winter recreationists with the goal of seeking undisturbed snow can visit locations on the forest where OSV use is less likely to occur or where it is prohibited such as at many sno-park locations throughout the State, reserved cross-country ski areas, and wilderness areas. Additionally, motorized use is prohibited in state parks, national parks, and national monuments and recreationists can seek out undisturbed snow scapes in these locations.

Comment #12-2: The DEIR underestimates future snowmobile emissions.

Response to Comment #12-2: The DEIR reasonably estimates future snowmobile emissions assuming a fleet composition comprised of 20 percent four-stroke engines and 80 percent two-stroke engines. The commenter's remark that new EPA 2012-compliant OSVs produce more hydrocarbon and carbon monoxide emissions than a typical 1998 two-stroke snowmobile is misleading for two reasons. First, the EPA's 2012 maximum family emission limits for hydrocarbons (150 grams per kilowatt-hour (112 grams/horsepower-hour)) and carbon monoxide (400 grams per kilowatt-hour (298 grams/horsepower-hour)) is approximately 20 percent less than the average hydrocarbon (141 grams per horsepower-hour) and 25 percent less than the average carbon monoxide (386 grams per horsepower-hour) emission factors referenced by the commenter. Second, the commenter compares hourly emissions for two different engine sizes, a 1998 model, 36-horsepower snowmobile and a 2010 model, 48-horsepower snowmobile. This is an improper comparison since larger engines will inherently produce more emissions than smaller engines over a specified time period due to their capacity to combust larger amounts of fuel. The EPA's regulations will, on average, reduce emissions for similarly sized engines.

Comment #12-3: Exhaust emissions may be greater than quantified in the DEIR.

Response to Comment #12-3: Comment noted. Actual emissions will vary depending on a number of factors that cannot be definitively predicted at this time, including weather, fleet composition, fleet maintenance, and visitation rates. The DEIR, however, uses past experience with recreational use levels and equipment to make reasonable assumptions regarding these factors; Table 4-13 of the DEIR provides a reasonable estimate of the snowmobile emissions that are likely to occur under baseline and program growth conditions.

Oral Comments Received at the OHMVR Division Meeting, October 27, 2010

Comment #13: Patrick Lieske, Lassen National Forest, Wildlife Biologist

Comment #13-1: Effectiveness of USFS monitoring efforts for goshawk PAC may not be fully addressing impacts related to OSV use. USFS monitoring of PACS is related to timber sales not OSV use near trails.

Response to Comment #13-1: A regional study on the effects of OHV/OSV use on northern goshawks is being conducted by the USFS Pacific Southwest Region (see Draft EIR, Section 5.3.2.1). See the response to Comment # 1-2.

Comment #13-2: OSV use still occurs on the forest even when low snow conditions exist and winter trails are closed for the season by forest order.

Response to Comment #13-2: As noted, roads within the forest are closed to wheeled vehicles during the winter by forest order which opens the roads to OSV use as snow cover permits. Lassen National Forest does not have a minimum snow depth requirement for OSV use, which means OSV travel can occur in low snow conditions. In general, OSV riders avoid substantial contact with bare soil out of concern for damage to their sleds. The EIR concludes the environmental damage to soils and water quality associated with OSV use in low snow conditions is less than significant (see Draft EIR, Section 6.3.2). Biological impacts associated with OSV use in low snow conditions are of concern and are addressed in Draft EIR Section 5.3.2.2 (Special-Status Plants) and Section 5.3.2.3 (Riparian, Wetland, and Other Sensitive Aquatic Communities). Incidental OSV use in low snow conditions is unlikely to create significant biological impacts. However, if OSV use occurs repeatedly in the same area under low snow conditions, then significant adverse biological impacts are likely. Measures BIO-4 and BIO-5 require additional USFS monitoring to address this issue and ensure biological resources are being adequately protected (see Draft EIR, Section 5.4).

Comment #14: Byron Baker

Comment #14-1: Snowcat operated at Bassetts needs to be replaced. Bassetts would have more volunteer groomers if snowcat equipment was reliable.

Response to Comment #14-1: See Response to Comment #6-1.

Comment #14-2: Limited parking is available at Bassetts trailhead. When parking at Yuba Pass fills up, overflow parking spills over to Bassetts. When Bassetts trailhead parking is full, it spills over to the parking area used by residents of Green Acres subdivision. There is room to expand Yuba Pass parking area and this could alleviate OSV parking shortage affecting Green Acres residents.

Response to Comment #14-2: The Bassetts trailhead provides parking for approximately 30 vehicles. Yuba Pass is operated as a sno-park and is not funded as part of the OSV Program. Residents of Green Acres, located off Gold Lake Road/Green Road at State Route 49, do not have plowed winter access to their homes and therefore compete for parking space along Gold Lake Road/State Route 49 with OSV users. As noted, expanding parking in this area such as the Yuba Pass parking area would increase winter recreation parking which could lessen the demand and make it easier for residents of Green Acres to find parking. However, it is not the role of the OSV Program to secure parking for subdivision residents.

3.0 TEXT AMENDMENTS

Page S-3, Table S-1

Table 3-1. Summary of Project Impacts and Mitigation Measures	
~~**IMPACT:** Total project direct and indirect GHG baseline (Year 2010) emissions are estimated at 27,118 MTCO2e. These are existing emissions that already occur and represent no new emissions to the statewide GHG emission inventory.~~ ~~**Less than Significant Impact**~~	~~**No mitigation required.**~~
IMPACT: Total project direct and indirect GHG emissions for 2010 Project Baseline are estimated at 27,118 MTCO2e. Program growth by Year 2020 would increase in GHG emissions to 32,069 MTCO2e which is an increase of 4,951 MTCO2e above 2010 Project ~~b~~Baseline conditions. No standards for GHG emissions apply to statewide mobile emissions, particularly from off-highway recreation vehicles. Therefore the Project does not conflict with applicable plans. The increases in GHG emissions under 2010 Project Baseline conditions and 2020 Program Growth conditions are ~~is~~ less than several significance thresholds used by several air quality management districts governing stationary sources and land use developments. **Less than Significant Impact**	**No mitigation required.**
BIOLOGICAL RESOURCES	
IMPACT: Northern spotted owls and northern goshawks occur within or near the Project Area. USFS actively monitors nesting habits and fledgling success. Management actions are currently in place that reduce the potential effects of OSV recreation on northern goshawks and northern spotted owls to a less than significant level. The USFS employs adaptive management. Thus, based upon the results of the Regional Northern Goshawk Focused Study and the Northern Spotted Owl Focused Study, biologists may revise the USFS Management Actions. **Less than Significant Impact**	**Measure BIO-1:** USFS shall ~~incorporate~~ review the results of the northern goshawk and northern spotted owl focused studies ~~into~~ and adjust implementation of ~~m~~Management ~~a~~Actions as needed to address significant disturbance. If any such modification to Management Actions is necessary, the USFS shall ~~and~~ report the~~se~~ ~~actions~~ changes to the OHMVR Division for incorporation into the OSV Program ~~as soon as revised USFS management actions are formulated~~. The need for implementing a Management Action, such as an LOP or route closure, for a particular nest site would be determined based upon the results of the focused studies and site-specific information related to the specific individual or pair such as observations of individuals being disturbed (e.g., owl or goshawk flying off of nest or roost) as OSV use occurs, evidence of nest failure that appears to be linked to OSV use, proximity of the OSV use to known nests, overlap of timing of OSV use with reproductive season, and local topography. **Less than Significant Impact After Mitigation.**

Table 3-1. Summary of Project Impacts and Mitigation Measures	
IMPACT: California wolverine is not known to be present near OSV sites. If present, disturbance caused by OSV activities may adversely affect California wolverine natal denning behaviors. **Potentially Significant Impact**	**Measure BIO-2:** USFS shall continue to work with the Pacific Southwest Research Station and other partners to monitor for presence of California wolverine. If there are any verified wolverine sightings, a USFS or other qualified biologist shall conduct an analysis to determine if OSV use within 5 miles of the detection have a potential to affect ~~wolverine~~ a natal denning site and, if necessary, a LOP from January 1 to June 30, route closure, or reroute will be implemented to avoid adverse impacts to potential breeding. The determination of the need for an LOP or other action shall take into account topography, other barriers between the OSV use and the known or likely den site, proximity of known or likely OSV use, and any other factors that may affect the level of disturbance. **Less than Significant Impact After Mitigation.**

Page S-4, Table S-1

Table 3-2. Summary of Project Impacts and Mitigation Measures	
IMPACT: Disturbance caused by OSV activities may adversely affect Sierra Nevada red fox breeding behaviors, home range use, and/or establish trailhead scavenging and begging behaviors. **Potentially Significant Impact**	**Measure BIO-3:** Educational materials shall be provided at each trailhead concerning the ~~on~~ red fox and the importance of minimizing direct contact with ~~red foxes at each trailhead~~ this species. USFS shall provide the results of Sierra Nevada red fox inventory and monitoring currently being performed by wildlife biologists from the ~~Forest Service~~ USFS, CDFG, and the University of California, Davis, to the OHMVR Division.…

Page S-5, Table S-1

Table 3-3. Summary of Project Impacts and Mitigation Measures	
	Measure BIO-4: ….(3) Annually monitor the groomed trail system and adjacent concentrated-use riding areas where plants listed in Table 5-6 have a potential for occurrence. Monitoring shall focus on locations that are chronically exposed to OSV use and where plants listed in Table 5-6 have a potential for occurrence and exposure to OSV impacts. If this monitoring reveals <u>significant</u> impacts, <u>such as plants that have been crushed or seedbanks damaged by OSV tracks,</u> USFS shall implement protective measures (e.g., temporary fencing, barriers, seasonal closures, signage, trail re-routes, public education, etc.) to restrict access and prevent further damage to these plants and engage in public education. Follow-up monitoring shall be conducted to ensure that protective measures are implemented and effective.
IMPACT: Chronic disturbance caused by OSVs riding during low-snow conditions over wetlands, riparian areas, streams, and lake ice can adversely affect aquatic communities. **Potentially Significant Impact**	**Measure BIO-5:** USFS shall annually monitor aquatic resources in the Project Area near the groomed trail system for damage by OSV use during low-snow conditions. If these assessments reveal <u>significant</u> impacts, <u>such as multiple OSV tracks through sensitive aquatic environments or crushed/damaged riparian vegetation,</u>USFS shall implement protective measures (e.g., fencing, signage, trail reroutes, etc.) to restrict access and prevent further resource damage and engage in public education.

Page S-6, Table S-1

Table 3-4. Summary of Project Impacts and Mitigation Measures	
NOISE	
IMPACT: Equipment noise from snow grooming and plowing and noise from OSV recreation use would occur. Noise from plowing would occur on roads consistent with vehicle noise. Trail grooming noise occurs in late night hours when outdoor recreation is generally not occurring. ~~OSV engine noise is audible to other motorized and non-motorized recreationists using the national forest. Noise levels fall within acceptable range for outdoor recreation.~~ A stationary person on the trail could be exposed to OSV noise ranging from 45 dB to 80 dB at the moment of passage, and lasting roughly one to three minutes depending on environmental conditions, OSV speed and number of users. Anyone within 500 to 1200 feet of a busy trail would hear consistent OSV noise, well above the normally quiet background noise levels of 35 to 45 dBA Leq, depending on wind. OSV noise levels can conflict with non-motorized recreationists using the OSV Program Project Area who prefer a quiet experience. However, forest plans (LRMPs) do not have quantified ambient noise standards for forest activities and OSV recreation is a permissible use established by forest plans. Exposure of non-motorized recreationists to OSV noise in the Project Area is voluntary. Exclusive non-motorized winter recreation areas are available at other areas on forest lands, wilderness areas, state parks, national parks, and national monuments. **Less than Significant Impact**	**No mitigation required.**

Page 2-15, Table 2-6, Contract Agency/Service Provider at Morgan Summit trailhead

Table 2-6. OSV Program, Plowed Access Roads and Trailheads	
National Forest/Trailhead	**Contract Agency/Service Provider**
Lassen/Ashpan	Lassen NF~~/Caltrans~~
Lassen/Bogard	Lassen NF~~/Caltrans~~
Lassen/Swain Mountain	~~Plumas County~~ Lassen NF
Lassen/Morgan Summit	Lassen NF/~~Caltrans~~ Lassen Volcanic National Park

Page 3-8, Table 3-2, Special Interest Area at Morgan Summit

Table 3-2. Special Interest Areas in Project Area Vicinity

National Forest	OSV Trail System	Widlerness, Geographic, and Cultural Special Interest Areas
~~Lassen~~	~~Morgan Summit~~	~~Lassen Volcanic National Park~~

Page 3-12, last paragraph

Lassen National Forest. Two trespass issues originate in the Lassen National Forest: Lassen Volcanic National Park near Eskimo Hill and Caribou Wilderness near Echo Lake and Cone Lake. Trespass into Lassen Volcanic National Park likely originates from ~~Ashpan or Morgan Summit~~ Bogard or Swain Mountain trailhead, while trespass into Caribou Wilderness likely begins at the Chester-Almanor, Swain Mountain, or Bogard trailheads trailhead. Intrusion into Lassen Volcanic National Park is not known to be a chronic problem by USFS or National Park staff. Intrusion into Caribou Wilderness area is believed to occur due to poor signage and no distinct geographic feature that delineates the wilderness area boundary. However, this problem is not considered to be chronic by USFS staff.

Page 3-14,Table 3-3, Orgin of OSV Intrusion at Lassen Volcanic National Park

<table>
<tr><th colspan="4">Table 3-3. OSV Intrusion Areas, 2009</th></tr>
<tr><th>National Forest</th><th>OSV Intrusion Area</th><th>Origin of OSV</th><th>Patrol Type/ Frequency</th></tr>
<tr><td>Lassen</td><td>Lassen Volcanic National Park near Eskimo Hill</td><td>~~Ashpan or Morgan Summit~~ Bogard or Swain Mountain</td><td rowspan="2">LEO weekends
FPO weekdays</td></tr>
<tr><td>Lassen</td><td>Caribou Wilderness near Echo Lake and Cone Lake</td><td>Swain Mountain, Bogard, Chester-Almanor</td></tr>
</table>

Page 3-17, Biology; Growth in OSV Recreation, last sentence

As described in Section 3.3.2.1 above, implementation of ~~Measure BIO-3~~ Measure BIO-4 would bring the OSV Program into ~~to~~ conformance with LRMP S&Gs and management prescriptions governing biological resources.

Page 3-23, Measure BIO-4

Measure BIO-4: (see Biology, Section 5.4)
Implementation: by OHMVR Division and USFS
Effectiveness: Completion of inventories and implementation of protective measures would minimize significant impacts on special-status plant species from OSV operations.

Feasibility: Feasible
Monitoring: USFS shall submit completed inventories to OHMVR Division for review. USFS shall maintain a log of monitoring efforts and protective measures taken ~~any management actions implemented to protect sensitive status plants~~. This log shall be submitted to OHMVR Division ~~for agency review each summer~~ mid and end of season, and no later than June 30 for review prior to contract approval for OSV Program operations for the following winter season.

Page 3-24, Measure LU-1, Monitoring

Implementation: by USFS and OHMVR Division
Effectiveness: Existing management actions have been effective at preventing wilderness trespass from becoming an escalating chronic condition. With continued management and implementation of focused enforcement actions, wilderness incursions would not be eliminated but would be minimized to a less than significant level.
Feasibility: Feasible; the USFS and OHMVR Division have implemented focused enforcement actions previously to resolve trespass issues.
Monitoring: ~~National forests shall submit patrol logs and statement of needed management actions to OHMVR Division at end of each snow season and prior to OHMVR Division release of OSV Program funds to the national forests for the following winter season.~~ National forests shall submit to the OHMVR Division monthly patrol logs, covering the entire OSV recreation season, showing monitoring and implementation of any site-specific measures, including enforcement actions. The first set of patrol logs shall be mid season and the second set shall be submitted no later than June 30. The OHMVR Division shall review the logs prior to invoice payment and contract approval for OSV Program operations for the following winter season.

Page 4-33, Indirect Emissions: OSV Use and Passenger Vehicle Travel.

Table 4-16 indicates 2010 Project Baseline GHG emissions from OSV use and visitor travel to and from the Project Area ~~are not new emissions but rather a continuation of current conditions. Although these current conditions are contributing toward the statewide exceedance of the GHG emissions levels in excess of the 1990 rollback goal specified for the state, the impact is not considered significant as it is not a net increase above the current baseline and is not a net increase in GHG.~~ would be 26,492 MTCO$_2$e, and overall 2010 Project Baseline GHG emissions would be 27,118 MTCO$_2$e. The OHMVR Division has not adopted quantitative standards of significance for GHG emissions or potential global climate change impacts. As identified in Section 4.3.1.3 above, several air districts have developed numerical GHG emissions thresholds of significance, however, these thresholds do not apply to the proposed statewide scope of the OSV Program activities. The OSV Program is a statewide recreational project that produces GHG from mobile sources that are not under the permitting control of any one agency and therefore an efficiency based threshold, which normalizes GHG emissions for project size, provides the most appropriate benchmark for considering the significance of the 2010 Project Baseline. Under the 2010 Project Baseline condition the project would accommodate approximately 200,000 visitors and produce approximately 27,118 MTCO$_2$e, or approximately 0.14 MTCO$_2$e per visitor, a value considerably less than the BAAQMD's 4.6 MTCO2e per capita threshold, which was derived from CARB's AB32 GHG inventory and is an estimate of the amount of land-use related GHG emissions that each state resident and employee could emit in Year 2020 without impeding GHG reduction goals of AB32.

There are currently no plans which specifically address recreation fuel use. Several statewide plans address transportation fuel use and GHG emissions generally. The OSV Program is not specifically in conflict with these plans as it does not impede their implementation. The Project Baseline condition would result in direct and indirect GHG emissions that would not impede the GHG reduction goals of AB32 nor exceed the efficiency metric threshold established by the BAAQMD. The individual on- and off-road equipment that produces these emissions would be subject to voluntary and regulatory actions developed under AB32 and would not conflict with any GHG reduction plan. The 2010 Project Baseline condition GHG emissions are considered less than significant.

Page 4-34, Greenhouse Gases Impact

The Year 2020 Program Growth condition results in a total GHG emission of 32,069 MTCO2e which is an increase of 4,951 MTCO2e above 2010 Project B~~b~~aseline conditions (Table 4-16 and 4-17). This section analyzes ~~the difference of~~ this GHG emissions increase.

Page 4-35, Growth in OSV Recreation, first paragraph

Growth in OSV Recreation. Growth in OSV use levels over the 10-year program period would increase the GHG emissions generated by OSV use and passenger vehicle travel. As described in Project Description Section 2.7.2.1 an average annual growth rate of 4% is assumed in this analysis. OSV recreation in the Project Area has occurred historically and roughly one-third of OSV use would continue to occur without the OSV Program based on visitor survey (Project Description Section 2.6.1.2). The analysis presented below quantifies GHG emissions from all OSV use occurring in the Project Area and attributes it to the OSV Program resulting in a highly conservative estimate of project impacts. Actual GHG emissions associated with the OSV use and user transportation are likely to be two-thirds of the totals shown in Table 4-17.
The increase of 31,283 MTCO2e above existing conditions without the OSV Program and the increase of 4,791 MTCO2e above 2010 Project Baseline conditions from indirect project emissions from OSV use and passenger vehicle travel (**Error! Reference source not found.** and **Error! Reference source not found.**) could conflict with the state goal to roll back GHG emissions to 1990 GHG levels of 427 $MMTCO_2e$. With a "business-as-usual" approach, CARB forecasts the statewide GHG emissions will rise to 596.4 MMT. Although the OHMVR Division has not adopted its own quantitative standards of significance for GHG emissions and potential global climate change impacts, the state goal of a roll-back to 1990 GHG emissions levels is a quantitative target.

Page 4-35, Growth in OSV Recreation, third paragraph

Overall projected growth of the OSV Program by 2020 would increase total GHG emissions from all sources (indirect and direct) ~~27,118 $MTCO_2e$ (2010)~~ to 32,069 $MTCO_2e$ (~~2020)~~ above existing conditions without the OSV Program resulting in a net increase of 4,951 $MTCO_2e$ above 2010 Project Baseline conditions. This increase is more than the BAAQMD land use project threshold of 1,100 $MTCO_2e$ and the SCAQMD residential/commercial project threshold of 3,000 $MTCO_2e$, ~~but less~~ and more than the10,000 $MTCO_2e$ stationary source level that both the

SCAQMD and BAAQMD have established for stationary source projects. These thresholds, however, are not applicable to a state-wide recreational project such as the OSV Program.

Page 5-17, Table 5-5, addition of golden eagle text

Table 3-5. USFS Management Actions for Special-Status Wildlife Species, OSV Program		
Special-Status Species[1]	**Location and Habitat**	**USFS Management Action**
golden eagle (SFP)	Rolling foothills, mountain areas, sage-juniper flats, and desert. Cliff-walled canyons and large trees in open areas provide nesting habitat in most parts of it range.	**Inyo and Modoc National Forests**: Limit human disturbance, including OHV use, within 1/4 mile of nest sites from Feb. 1-June 30.

Page 5-34, first full paragraph, Breeding Disruption

….With the implementation of the Management Actions already in use (Table 3-5) by the national forests and Mitigation Measures BIO-1 and 2 identified below in Section 5.4, the project impacts during early courtship and nesting/denning periods would remain at existing less-than-significant levels. No new impacts would occur as a result of the continuation of the OSV Program and therefore, the Project's effect on special-status birds remains ~~is~~ less than significant.

Page 5-34, last paragraph, Coyote Incursion

….Competition and predation, if occurring, would be predictably restricted to areas in the immediate vicinity of trails and is considered less than significant. The use of OSV trails and regular grooming is an existing condition that has been in operation for numerous years; and no new trail expansion is proposed at this time. Therefore, coyote incursion, if occurring, would continue, but would not be increased by OSV Program activities.

Page 5-36, first partial paragraph

….With the implementation of the Management Actions already in use by the national forests, the project noise impacts to birds during early courtship and nesting periods would remain at existing less-than-significant levels. No new impacts would occur as a result of the continuation of the OSV Program and therefore, the Project's effect on special-status birds remains ~~is~~less than significant.

Page 5-36, new text inserted after Bald Eagle

Golden Eagle

Very little research has been performed showing golden eagle response to OSVs. Most studies looking at eagle response to human disturbance involve bald eagles. Some of those studies have shown the response of eagles to human activities is variable. Individual eagles show different thresholds of tolerance for disturbance. The distance at which a disturbance causes bald eagles to modify their behavior also is affected by the sight distance of the motorized use. For example, forested habitat can reduce the noise generated by motorized activity. In addition, if the noise-generating activity is hidden from the nest site, disturbance thresholds may be reduced. Studies that do involve golden eagle and human disturbance typically report golden eagles seem to be more sensitive to humans afoot than to vehicular traffic (Holmes et al. 1993; Hamman 1999). One study in Yellowstone National Forest showed there were only two responses by golden eagle to human presence: no visible response or the individual looked at the OSVs or humans and resumed their previous activity (McClure et al. 2009).

In the Californian Sierra Nevada and Cascade mountains, golden eagles nest on cliffs in rugged, open habitats with canyons and escarpments. In monitoring results reported under the Division's OHV Grants Program, three national forests reported nesting typically does not occur within close proximity to OHV trails. According to the USFS, disturbance from OSV use is not likely due to distance of OHV routes from suitable habitat (rocky cliffs). Suitable nesting habitat is typically protected by high cliffs (where OSVs are not expected to occur) and no take has been documented by USFS as a result of ongoing OHV/OSV activities. However, two forests with populations of golden eagles provide for management direction in their LRMPs. Inyo and Modoc National Forests restrict human disturbance within ¼ mile of active nests after February 1 (Table 3-5). No significant effect on golden eagle from OSV activity has been determined. Given the lack of documented effects, the species' listing status (not listed under the state or federal ESA and not a California Species of Special Concern, and that golden eagle nesting does not typically occur within close proximity to OSV trails, the project impact to golden eagle is considered less than significant.

Page 5-47, Wildlife Movement Corridors, last sentence of paragraph

The continuation of this funding as proposed by the Project would not change the extent of existing less-than-significant effects.

Page 5-51, Measure BIO-1

Measure BIO-1: USFS shall ~~incorporate~~ review the results of the northern goshawk and northern spotted owl focused studies ~~into~~ and adjust implementation of ~~m~~Management ~~a~~Actions as needed to address significant disturbance. If any such modification to Management Actions is necessary, the USFS shall ~~and~~ report the~~se~~ ~~actions~~ changes to the OHMVR Division for incorporation into the OSV Program ~~as soon as revised USFS management actions are formulated~~. The need for implementing a Management Action, such as an LOP or route closure, for a particular nest site would be determined based upon the results of the focused studies and site-specific information related to the specific individual or pair such as observations of individuals being disturbed (e.g., owl or goshawk flying off of nest or roost) as OSV use occurs, evidence of nest failure that appears to be linked to OSV use, proximity of the OSV use to known nests, overlap of timing of OSV use with reproductive season, and local topography.

Implementation:	By OHMVR Division and USFS
Effectiveness:	Implementation of updated management actions would ensure the effects of OSV operations and recreation on northern goshawk and northern spotted owl remain less than significant.
Feasibility:	Feasible
Monitoring:	USFS shall maintain a log of monitoring efforts and ~~any management actions~~ protective measures taken to protect northern goshawk and northern spotted owl. This log shall be submitted to OHMVR Division ~~for review each summer~~ mid and end of season, and no later than June 30 for review prior to contract approval for OSV Program operations for the following winter season.

Page 5-51, Measure BIO-2

Measure BIO-2: USFS shall continue to work with the Pacific Southwest Research Station and other partners to monitor for presence of California wolverine. If there are any verified wolverine sightings, a USFS or other qualified biologist shall conduct an analysis to determine if OSV use within 5 miles of the detection have a potential to affect ~~wolverine~~ a natal denning site and, if necessary, a LOP from January 1 to June 30, route closure, or reroute will be implemented to avoid adverse impacts to potential breeding. The determination of the need for an LOP or other action shall take into account topography, other barriers between the OSV use and the known or likely den site, proximity of known or likely OSV use, and any other factors that may affect the level of disturbance.

Implementation: By OHMVR Division and USFS
Effectiveness: Implementation would prevent significant impacts to California wolverine from OSV operations.
Feasibility: Feasible; required by SNFPA S&G #32.
Monitoring: USFS shall maintain a log of monitoring efforts and any management actions taken to protect California wolverine from OSV use impacts. This log shall be submitted to OHMVR Division ~~for review each summer~~ no later than June 30 for review prior to contract approval for OSV Program operations for the following winter season.

Page 5-52, Measure BIO-3

Measure BIO-3: Educational materials shall be provided at each trailhead concerning the ~~on~~ red fox and the importance of minimizing direct contact with ~~red foxes at each trailhead~~ this species. USFS shall provide the results of Sierra Nevada red fox inventory and monitoring currently being performed by wildlife biologists from the ~~Forest Service~~ USFS, CDFG, and the University of California, Davis, to the OHMVR Division….

Implementation: By OHMVR Division and USFS
Effectiveness: Implementation of inventory and management actions would prevent significant impacts to Sierra Nevada red fox populations from OSV operations.
Feasibility: Feasible; required by SNFPA S&G #32.
Monitoring: USFS shall provide an inventory report and maintain a log of monitoring efforts and any management actions taken to protect Sierra Nevada red fox. This log shall be submitted to OHMVR Division no later than June 30 for review each summer prior to contract approval for OSV Program operations for the following winter season.

Page 5-53, Measure BIO-4, third paragraph

3) Annually monitor the groomed trail system and adjacent concentrated-use riding areas where plants listed in Table 5-6 have a potential for occurrence. Monitoring shall focus on locations that are chronically exposed to OSV use and where plants listed in Table 5-6 have a potential for occurrence and exposure to OSV impacts. If this monitoring reveals significant impacts, such as plants that have been crushed or seedbanks damaged by OSV tracks, USFS shall implement protective measures (e.g., temporary fencing, barriers, seasonal closures, signage, trail re-routes, public education, etc.) to restrict access and prevent further damage to these plants and engage in

public education. Follow-up monitoring shall be conducted to ensure that protective measures are implemented and effective.

Implementation: By OHMVR Division and USFS
Effectiveness: Completion of inventories and implementation of protective measures would minimize significant impacts on special-status plant species from OSV operations.
Feasibility: Feasible
Monitoring: USFS shall submit completed inventories to OHMVR Division for review. USFS shall maintain a log of monitoring efforts and protective measures taken ~~any management actions implemented to protect sensitive status plants~~. This log shall be submitted to OHMVR Division ~~for agency review each summer~~ mid and end of season, and no later than June 30 for review prior to contract approval for OSV Program operations for the following winter season.

Page 5-53, Measure BIO-5

Measure BIO-5: USFS shall annually monitor aquatic resources in the Project Area near the groomed trail system for damage by OSV use during low-snow conditions. If these assessments reveal significant impacts, such as multiple OSV tracks through sensitive aquatic environments or crushed/damaged riparian vegetation, USFS shall implement protective measures (e.g., fencing, signage, trail reroutes, etc.) to restrict access and prevent further resource damage and engage in public education.

Implementation: By OHMVR Division and USFS
Effectiveness: Would prevent significant impacts to aquatic communities from OSV operations.
Feasibility: Feasible; requires increased resource monitoring efforts by USFS.
Monitoring: OHMVR Division shall modify the OSV Program Checklist used by national forests (Appendix C) to include monitoring for damage to aquatic resources. USFS shall maintain a monitoring log along with results, any protective measures taken, and success rate. This log shall be submitted to the OHMVR Division no later than June 30 for review ~~each summer~~ prior to contract approval for OSV Program operations for the following winter season.

Page 7-5, OSV Use

OSV Use. ~~OSV use is allowable in national forests as designated by the governing LRMP. The audibility of the OSV is largely affected by atmospheric conditions, the terrain and vegetation surrounding the trail routes, the speed of OSV travel, and the number of OSV users.~~ The OSV Program ~~Project~~ facilitates increased OSV use along trail routes in the Project Area that have been previously used for wintertime recreation including motorized vehicles (Project Description, Section 2.6.1.2). ~~At current OSV use rates, the OSV Program at 2010 baseline levels would not generate an increase the ambient noise levels associated with OSV use above historical seasonal levels.~~ The increased OSV activity has the potential to increase the noise exposure of other visitors recreating near the project trails.

Noise from snowmobiles manufactured after June 30, 1976 have a noise emission of 73 dBA at 50 feet while traveling at 15 mph when tested under SAE J1161 procedures. This is the equivalent of a single passenger vehicle or motorcycle on a roadway. A snowmobile under full throttle emits the same sound level as a truck pulling a camper at a constant highway speed applying very little throttle. In a worst case scenario, a snowmobile leaving a stop sign and applying full throttle, the noise produced is still about the same as a passenger vehicle driving down the road (International Snowmobile Manufacturers Association 2008). ~~The effect is audible but not long lasting.~~

The audibility of the OSV is largely affected by atmospheric conditions, the terrain and vegetation surrounding the trail routes, the speed of OSV travel, and the number of OSV users.

Sound levels from two or three OSVs travelling together will be 45 dB at 500 to 1200 feet, the latter in open country and the former in more heavily wooded country. Each passage would expose a stationary person on the trail to noise ranging from 45 dB to 80 dB at the moment of passage, and lasting roughly one to three minutes depending on environmental conditions. Hence, on a busy trail, anyone within 500 to 1200 feet, will hear consistent OSV noise, well above the normally quiet background noise levels of 35 to 45 dBA Leq , depending on wind.

Noise levels generated by OSVs in the Project Area are not subject to regulation by local general plan or noise ordinance given the location on federal land in national forests. National forest LRMPs do not have S&Gs which restrict noise levels of OSV recreation. Thus, OSV use facilitated by the OSV Program would not occur in excess of established ambient standards.

OSV use is allowable in national forests as designated by the governing LRMP. In the Project Area, OSV noise generated by the OSV Program occurs in a recreation area ~~open~~ authorized for OSV use by the LRMP of the individual national forests. Because the activity is occurring in a trail system area designated for motorized use, the noise exposure is expected by other trail users as part of the ambient noise conditions ~~and therefore does not conflict or substantially detract from the recreational experience of other trail users~~.

Noise from OSV use is audible to other users on the recreation trail, which may include cross-country skiers and snowshoers. ~~OSV use is restricted to specific trail locations in order to minimize conflicts between uses.~~ OSV trails are signed to indicate that OSV use is permissible

Page 7-6, OSV Use continued discussion

on these trails. Non-motorized users of the trail system know in advance that OSV use occurs on and off the trails in the Project Area and that project trails do not offer protection from intrusive sights or sounds of snowmobiles. As discussed in Recreation, Section 8.3.2.3, OSV noise can detract from the quality of recreation experienced by non-motorized trail users. Non-motorized trail users who might be sensitive to OSV noise have the option of choosing to recreate in areas closed to OSVs which occur on many of the national forests, state parks, national parks, and national monuments. ~~Continuation~~ Operation of the OSV Program at 2010 baseline levels would not expand OSV use into new areas presently unused by OSV or promote OSV infringement upon quiet areas reserved for non-motorized users such as Nordic skiers and snowshoers. OSV intrusion into closed quiet wilderness areas on national forests adjacent to the groomed trails does occur as described in Land Use Plans and Policies, Section 3.3.3.1. Continued and enhanced enforcement of closed area boundaries is required as project mitigation (Measure LU-1) for OSV intrusion into wilderness areas.

Given the 1,761 miles of groomed trails provided by the OSV Program, the quick dispersal rates between the motorized and non-motorized user groups, ~~and~~ the access to ~~wilderness areas from groomed trails~~ other areas on forest lands, state parks, national parks, and national monuments which are available exclusively to non-motorized use, the lack of a quantified ambient noise standard on the forests, and the establishment of OSV use throughout forest lands by forest plan, the current noise impacts of OSV use on non-motorized users in the Project Area is considered less than significant. ~~Continuation of the OSV Program at 2010 baseline levels would not expose sensitive receptors to increased noise levels above existing conditions and is therefore considered a less than significant impact~~.

Page 8-10, Table 8-3, overflow frequency at Morgan Summit trailhead

Table 8-3. OSV Program Parking Demand, Baseline 2010

National Forest	Trailhead	Parking Capacity	Weekday Demand	Max Day Demand	Overflow Requency
Lassen	Morgan Summit	16	4	14	~~None~~ Occasional

Page 9-10, Redirection of Grooming Funds, first paragraph, second to last sentence

This alternative would not necessarily stop grooming but would ~~substantially~~ reduce the frequency of grooming~~, leaving~~ which could leave the trail conditions rough.

Page 11-5, Bibliography, addition of new references

Hamann, B., H. Johnston, P. McClelland, S. Johnson, L. Kelly and J. Gobielle. 1999. Birds. In G. Joslin and H. Youmans, coordinators, Effects of recreation on Rocky Mountain wildlife: A Review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society. 307pp.

Holmes, T. L., R. L. Knight, L. Stegall, and G. R. Craig. Responses of wintering grassland raptors to human disturbance. Wildl. Soc. Bull.; 21:461-468. 1993.

McClure, C., D. Reinhart, P.J. White, M. Donovan, and B. Teets. Wildlife responses to motorized winter recreation in Yellowstone; 2009 annual report. Prepared by Yellowstone Center for Resources, National Park Service.

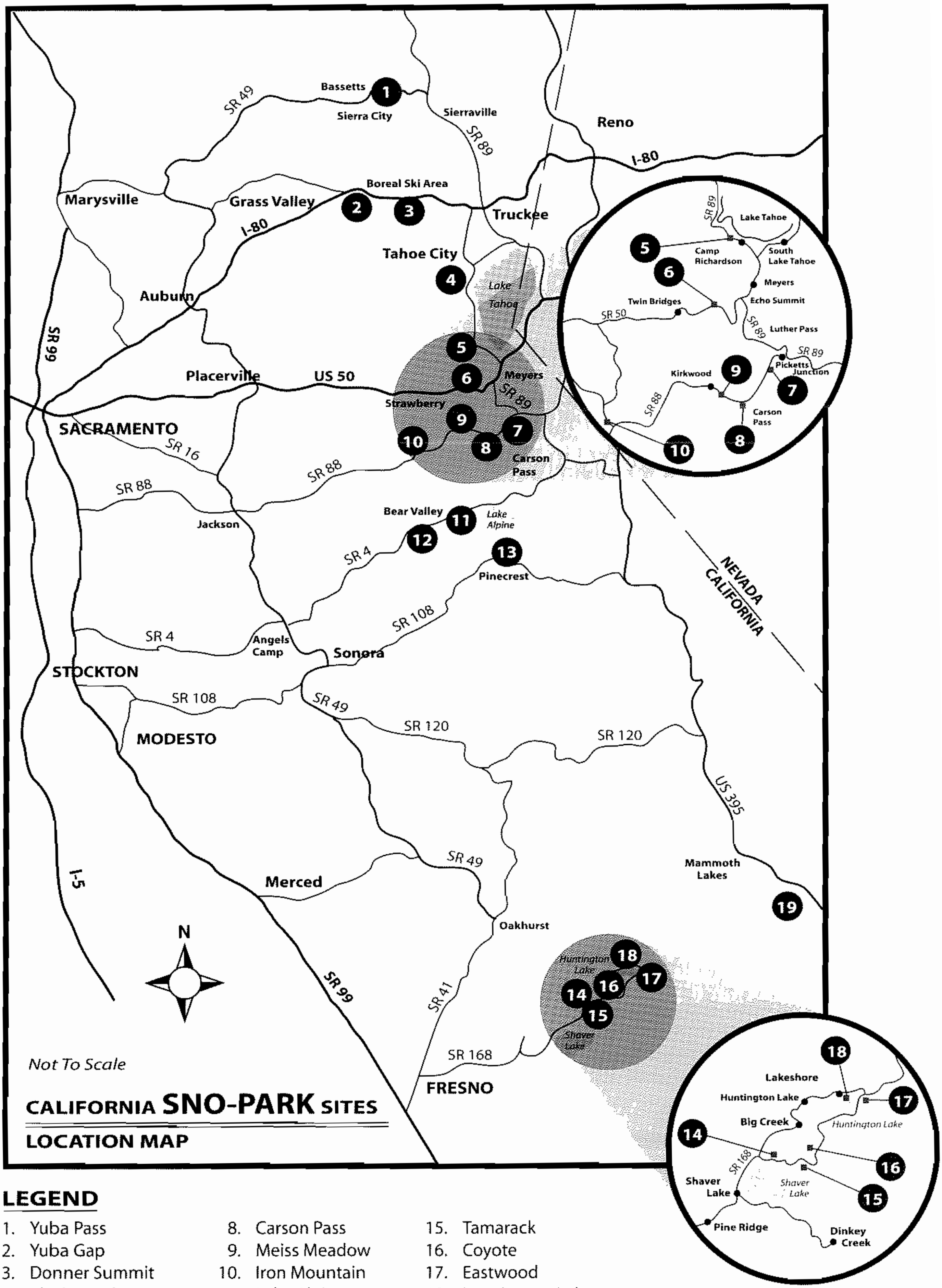
Page D-19, Appendix D Table 1

Table 1. USFS Forest-wide Standards and Guidelines Relevant to the OSV Program

9) Inyo (1988)	
Wildlife (p. 98)	Golden Eagle. Maintain or enhance the integrity of nesting habitats for golden eagles. Limit human disturbance within one-quarter mile of nest sites from February 1 through June 30. Provide for several successional stages and vegetation types within five miles of nest sites. Provide artificial ledges on cliffs where the lack of ledges is a limiting factor.

ATTACHMENT A

California Sno-Parks
California Department of Parks and Recreation



LEGEND

1. Yuba Pass
2. Yuba Gap
3. Donner Summit
4. Blackwood Canyon
5. Taylor Creek
6. Echo Lake
7. Hope Valley
8. Carson Pass
9. Meiss Meadow
10. Iron Mountain
11. Lake Alpine
12. Spicer
13. Highway 108
14. Balsam Meadows
15. Tamarack
16. Coyote
17. Eastwood
18. Huntington Lake
19. Rock Creek

SNO-PARKS

1. YUBA PASS
Located on the south side of Highway 49 at Yuba Pass. **Contact:** Tahoe National Forest, Sierraville Ranger District - (530) 994-3401.
GPS: 39°37'1.20"N, 120°29'23.10"W

2. YUBA GAP
Located on the south side of I-80 at the Yuba Gap exit. **Contact:** Tahoe National Forest, Sierraville Ranger District - (530) 994-3401.
GPS: 39°19'6.54"N, 120°36'8.70"W
No overnight parking, snowmobiling or busses

3. DONNER SUMMIT
Located on the south side of I-80 at the Castle Peak exit beyond Boreal Inn. **Contact:** Tahoe National Forest, Truckee Ranger District - (530) 587-3558.
GPS: 39°20'23.54"N, 120°20'38.25"W

4. BLACKWOOD CANYON
Located on the west side of Highway 89, three miles south of Tahoe City. **Contact:** Lake Tahoe Basin Management Unit - (530) 543-2600.
GPS: 39° 6'50.77"N, 120° 9'30.12"W
No overnight parking

5. TAYLOR CREEK
Located on the south side of Highway 89, just north of Camp Richardson Road. **Contact:** Lake Tahoe Basin Management Unit - (530) 543-2600.
GPS: 38°55'56.95"N, 120° 3'27.61"W

6. ECHO LAKE
Located on the north side of Highway 50 at Echo Lake Road. **Contact:** Lake Tahoe Basin Management Unit - (530) 543-2600.
GPS: 38°49'26.63"N, 120° 2'2.69"W
No snowmobiling

7. HOPE VALLEY
Located on the south side of Highway 88 at Blue Lakes Road. **Contact:** Humboldt-Toiyabe National Forest, Carson Ranger District - (775) 882-2766.
GPS: 38°44'53.70"N, 119°56'23.34"W

8. CARSON PASS
Located on the south side of Highway 88 near Carson Pass. **Contact:** Eldorado National Forest, Amador Ranger District - (209) 295-4251.
GPS: 38°41'42.72"N, 119°59'22.50"W
No snowmobiling

9. MEISS MEADOW
Located on the north side of Highway 88 near Carson Pass. **Contact:** Eldorado National Forest, Amador Ranger District - (209) 295-4251.
GPS: 38°41'46.81"N, 119°59'30.28"W
No snowmobiling

10. IRON MOUNTAIN
Located on the north side of Highway 88 at Mormon-Emigrant Trail Road. **Contact:** Eldorado National Forest, Amador Ranger District - (209) 295-4251.
GPS: 38°37'44.19"N, 120°12'49.87"W

11. LAKE ALPINE
Located at the winter closure gate on Highway 4. **Contact:** Stanislaus National Forest, Calaveras Ranger District - (209) 795-1381.
GPS: 38°28'54.20"N, 120° 1'2.46"W

12. SPICER
Located on the south side of Highway 4 at Spicer Road. **Contact:** Stanislaus National Forest, Calaveras Ranger District - (209) 795-1381.
GPS: 38°25'44.44"N, 120° 4'38.01"W

13. HIGHWAY 108
Located at the winter closure gate on Highway 108, east of Strawberry. **Contact:** Stanislaus National Forest, Summit Ranger District - (209) 965-3434.
GPS: 108, 38°16'1.47"N, 119°59'30.31"W

14. BALSAM MEADOWS
Located on the north side of Highway 168, east of Shaver Lake. **Contact:** Camp Edison - (559) 841-3134.
GPS: 37° 9'33.79"N, 119°14'33.84"W
No snowmobiling

15. TAMARACK
Located on the south side of Highway 168, east of Shaver Lake. **Contact:** Sierra National Forest, High Sierra Ranger District - (559) 855-5355.
GPS: 37° 9'45.02"N, 119°12'8.50"W

16. COYOTE
Located on the north side of Highway 168, east of Shaver Lake. **Contact:** Sierra National Forest, High Sierra Ranger District - (559) 855-5355.
GPS: 37°10'3.20"N, 119°12'22.92"W
No snowmobiling

17. EASTWOOD
Located on the east side of Highway 168 at Huntington Lake Road. **Contact:** Sierra National Forest, High Sierra Ranger District - (559) 855-5355.
GPS: 37°15'21.04"N, 119° 9'39.10"W

18. HUNTINGTON LAKE
Located on the west side of Huntington Lake Road, three miles from Eastwood SNO-PARK. **Contact:** Sierra National Forest, High Sierra Ranger District - (559) 855-5355.
GPS: 37°15'5.30"N, 119°10'27.23"W

19. ROCK CREEK
Located on the west side of Highway 395 at Rock Creek Road. **Contact:** Inyo National Forest, White Mountain Ranger District - (760) 873-2500.
GPS: 37°29'40.18"N, 118°43'3.39"W
No snowmobiling

RECOMMENDED ACTIVITIES

Cross-country Skiing | Dog Sledding
Snowmobiling | Snow Play

ATTACHMENT B

ANNUAL SNOWMOBILE REGISTRATIONS
California Department of Parks and Recreation, OHMVR Division

OSV Green Sticker Registration Annual Changes

YEAR	# OSV Registrations	Increase / Decrease from previous year
1990	8020	
1991	8849	10 %
1992	9837	10 %
1993	10941	9 %
1994	11844	9 %
1995	12712	9 %
1996	13569	9 %
1997	14050	10 %
1998	14913	9 %
1999	15878	9 %
2000	16945	9 %
2001	17838	9 %
2002	18986	9 %
2003	19902	5 %
2004	20758	4 %
2005	21598	4 %
2006	22487	4 %
2007	22882	2 %
2008	23202	1 %
2009	22413	-4 %
2010	21542	-4 %

United States
Environmental Protection
Agency

Air and Radiation

EPA420-F-02-033
September 2002

Office of Transportation and Air Quality

Frequently Asked Questions

Environmental Impacts of Newly Regulated Nonroad Engines

The U.S. Environmental Protection Agency (EPA) has adopted emission standards for recreational vehicles, recreational marine diesel engines, and industrial spark-ignition engines. This information sheet addresses questions about the environmental impacts of these engines and how this regulation will improve air quality.

What engines and vehicles are covered by the new standards?

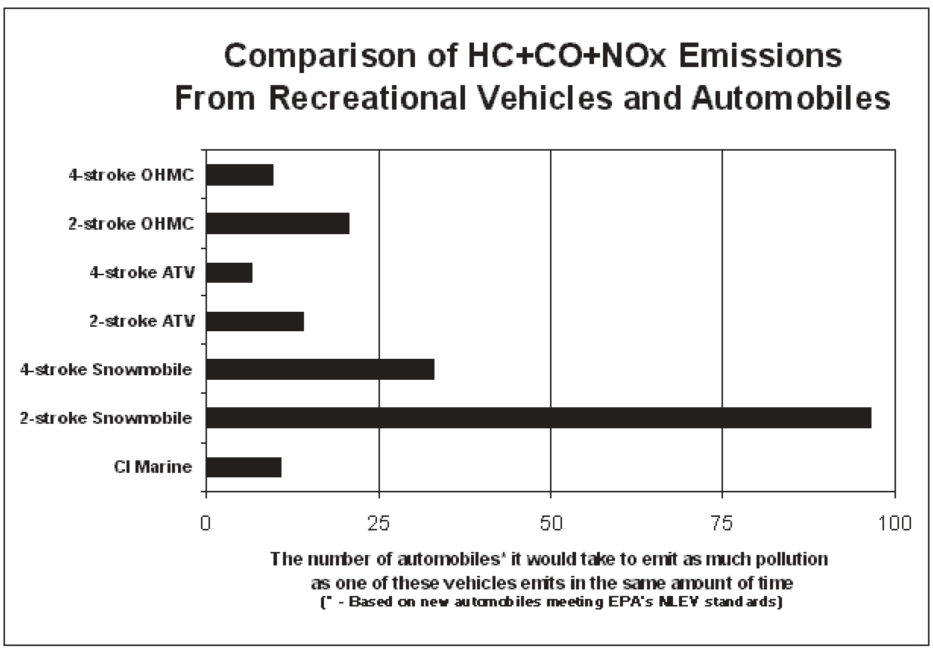
We are adopting new emission standards for the following three groups of previously unregulated nonroad engines and vehicles:

- Large industrial spark-ignition engines: Nonroad engines powered by gasoline, liquid propane gas, or compressed natural gas rated over 19 kilowatts (kW) (or 25 horsepower). These engines are used in commercial and industrial applications, including forklifts, electric generators, airport baggage transport vehicles, and a variety of farm and construction applications.
- Recreational vehicles: off-highway motorcycles, all-terrain vehicles (ATVs), and snowmobiles.
- Recreational marine diesel engines: Diesel engines rated at or above 50 horsepower (37 kilowatt) used in recreational boats, such as yachts and cruisers.

How do these engines and vehicles affect air quality?

Nationwide, these engines and vehicles are a significant source of air pollution. In 2000, they accounted for about 9 percent of national hydrocarbon (HC) emissions, 4 percent of carbon monoxide (CO) emissions, 3 percent of oxides of nitrogen (NOx) emissions, and 2 percent of particulate matter (PM) emissions from mobile sources. If left uncontrolled, by 2020 these engines will contribute 24 percent of national HC emissions, 6 percent of CO emissions, 9 percent of NOx emissions, and 5 percent of PM emissions from mobile sources. These estimates for 2020 show higher relative emission levels, both because of expected growth and because emission controls for cars, trucks, and other emission sources will substantially decrease total emissions.

On an individual basis, these vehicles can have very high emission rates. This is illustrated in the figure below, which compares the emissions from unregulated recreational vehicles with the emissions from an automobile meeting our current National Low Emission Vehicle (NLEV) emission standards. As shown in the figure below, an unregulated two-stroke off-highway motorcycle (OHMC) can emit as much pollution in one hour as over 20 automobiles operating for one hour. Similarly, an unregulated two-stroke snowmobile can emit as much as nearly 100 automobiles.



What are the human health and welfare effects of these pollutants?

The engines covered by the new standards generally contribute to ozone formation and ambient PM and CO levels. These pollutants are subject to our National Ambient Air Quality Standards (NAAQS); states that exceed NAAQS levels are required to take measures to reduce emissions. In addition, these engines emit Mobile Source Air Toxics.

Ozone

Ground-level ozone, the main ingredient in smog, is formed by complex chemical reactions of volatile organic compounds (primarily HC) and NOx in the presence of heat and sunlight. Ozone forms readily in the lower atmosphere, usually during hot summer weather. Volatile organic compounds come from some natural sources (such as vegetation), but mostly come from motor vehicles, chemical plants, refineries, factories, consumer and commercial products, and other industrial sources. NOx emissions come largely from motor vehicles, nonroad equipment, power plants, and other sources of combustion.

Elevated ozone concentrations remain a serious public health concern throughout the United States. In 2001, approximately 116 million people lived in 56 areas designated nonattainment under the 1-hour ozone NAAQS. Increased ozone concentrations in the air have been associated with increased hospitalizations for respiratory causes for individuals with asthma, worsening of symptoms, decrements in lung function, and increased medication use; chronic exposure may cause permanent lung damage. Children and people with compromised respiratory systems are particularly at risk.

Carbon Monoxide

CO is a colorless, odorless gas produced from the incomplete combustion of carbon-based fuels. CO enters the bloodstream through the lungs and reduces the delivery of oxygen to the body's organs and tissues. The health threat from CO is most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Healthy individuals also are affected, but only at higher CO levels. Exposure to elevated CO levels is associated with impairment of visual perception, work capacity, manual dexterity, learning ability and performance of complex tasks.

In 2001, approximately 22 million people lived in 13 areas designated nonattainment under the CO NAAQS. High concentrations of CO generally occur in areas with elevated mobile-source emissions. Peak concentrations typically occur during the colder months of the year when mobile-source CO emissions are greater and nighttime inversion conditions are more frequent.

Particulate Matter

Particulate matter represents a broad class of chemically and physically diverse substances. “Fine particulate matter” includes liquid and solid particles with a diameter of 2.5 microns or less (also known as $PM_{2.5}$). Particulate matter, like ozone, has been linked to a range of serious respiratory health problems, including premature mortality, aggravation of respiratory and cardiovascular disease, aggravated asthma, acute respiratory symptoms, chronic bronchitis, and decreased lung function.

According to our modeling, there were 65 million people living in areas with annual average $PM_{2.5}$ concentrations at or above the $PM_{2.5}$ NAAQS. PM emissions from various sources contribute directly to ambient PM levels. In addition, emissions of organic carbon, NOx and oxides of sulfur (SOx) indirectly contribute to ambient PM levels through atmospheric activity. Organic carbon accounts for 27 to 36 percent of fine-particle mass, depending on the area of the country. The vast majority (>90 percent) of direct PM emissions from mobile sources are in the fine-PM size range.

Air Toxics

Emissions from the engines covered by this final rule also contain several Mobile Source Air Toxics, including benzene, toluene, 1,3-butadiene, formaldehyde, acetaldehyde, and acrolein, which cause a variety of health-related problems. Users of these engines and vehicles may experience high levels of personal exposure to these substances. For example, snowmobile riders and those directly exposed to snowmobile exhaust emissions can be exposed to benzene levels two to three orders of magnitude greater than the 1996 national average benzene concentrations. These elevated levels are also known as air toxic “hot spots,” which are of particular concern to EPA.

Visibility

Fine PM is the major cause of reduced visibility in parts of the United States, including many of our national parks. In particular, HC emissions from snowmobiles in the winter months can contribute significantly to the organic carbon fraction of fine particles, which are largely responsible for visibility impairment. In Yellowstone National Park, a park with high snowmobile usage during the winter months, HC emissions from snowmobiles can exceed 500 tons per year, as much as several large stationary sources, and account for nearly 65 percent of annual HC emissions in the park.

How would the standards affect emissions and air quality?

When the emission standards for recreational vehicles, recreational marine diesel engines, and industrial spark-ignition engines are fully implemented, we expect an overall 71-percent reduction in HC emissions from these engines, an 80-percent reduction in NOx emissions, and a 57-percent reduction in CO emissions in 2020. These controls will help reduce ambient concentrations of ozone, CO, and fine PM. In addition, they will reduce personal exposure for people who operate, work with or are otherwise close to these engines and vehicles. They will also improve visibility in national parks.

What are the health benefits of the new standards?

The human health benefits of this rulemaking include avoiding approximately 1,000 premature deaths, preventing 1,000 hospital admissions, reducing 23,400 cases of asthma attacks, and reducing 200,000 days of lost work. In monetary terms, we estimate these health benefits to be roughly $8 billion in 2030. There are additional health and welfare benefits we are unable to quantify.

Where Can I Get More Information?

For more information on the environmental and health impacts of these new emission standards, see the Final Regulatory Support Document for this final rule (especially Chapter 1—Health and Welfare Concerns). You can access that document and others related to the rulemaking on our Web site at:

www.epa.gov/otaq/regs/nonroad/2002/cleanrec-final.htm

You can also contact us at:

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Air and Radiation

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Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines

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Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines

Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

Table of Contents

Executive Summary

EPA is adopting new standards for emissions of oxides of nitrogen, hydrocarbons, and carbon monoxide from several categories of engines. This Final Regulatory Support Document provides technical, economic, and environmental analyses of the new emission standards for the affected engines. The anticipated emission reductions will translate into significant, long-term improvements in air quality in many areas of the U.S. Overall, the requirements will dramatically reduce individual exposure to dangerous pollutants and provide much needed assistance to states and regions facing ozone and particulate air quality problems that are causing a range of adverse health effects, especially in terms of respiratory impairment and related illnesses.

Chapter 1 reviews information related to the health and welfare effects of the pollutants of concern. Chapter 2 contains an overview of the affected manufacturers, including some description of the range of engines involved and their place in the market. Chapter 3 covers a broad description of engine technologies, including a wide variety of approaches to reducing emissions. Chapter 4 summarizes the available information supporting the specific standards we are adopting, providing a technical justification for the feasibility of the standards. Chapter 5 applies cost estimates to the projected technologies. Chapter 6 presents the calculated contribution of these engines to the nationwide emission inventory with and without the standards. Chapter 7 compares the costs and the emission reductions for an estimate of the cost-effectiveness of the rulemaking. Chapter 8 presents our Final Regulatory Flexibility Analysis, as called for in the Regulatory Flexibility Act. Chapters 9 and 10 describe the societal costs and benefits of the rulemaking. Chapter 11 presents a range of regulatory alternative we considered in developing the final rule.

There are three sets of engines and vehicles covered by the new standards. The following paragraphs describe the different types of engines and vehicles and the standards that apply.

Emission Standards

Large industrial spark-ignition engines

These are spark-ignition nonroad engines rated over 19 kW used in commercial applications. These include engines used in forklifts, electric generators, airport ground service equipment, and a variety of other construction, farm, and industrial equipment. Many Large SI engines, such as those used in farm and construction equipment, are operated outdoors, predominantly during warmer weather and often in or near heavily populated urban areas where they contribute to ozone formation and ambient CO and PM levels. These engines are also often operated in factories, warehouses, and large retail outlets throughout the year, where they contribute to high exposure levels to personnel who work with or near this equipment as well as to ozone formation and ambient CO and PM levels. In this rulemaking, we call these “Large SI” engines.

We are adopting two tiers of emission standards for Large SI engines. The first tier, scheduled to start in 2004, sets standards of 4 g/kW-hr (3 g/hp-hr) for HC+NOx and 50 g/kW-hr (37 g/hp-hr) for CO. These standards are the same as those adopted earlier by the California Air Resources Board.

Starting in 2007, the Tier 2 emission standards fall to 2.7 g/kW-hr (2.0 g/hp-hr) for HC+NOx emissions and 4.4 g/kW-hr (3.3 g/hp-hr) for CO emissions. However, we are including an option for manufacturers to certify their engines to different emission levels to reflect the inherent tradeoff of NOx and CO emissions and to add an incentive for HC+NOx emission reductions below the standard. Generally this involves meeting a less stringent CO standard if a manufacturer certifies an engine with lower HC+NOx emissions. Table 1 shows several examples of possible combinations of HC+NOx and CO emission standards. The highest allowable CO standard for duty-cycle testing is 20.6 g/kW-hr (15.4 g/hp-hr), which corresponds with HC+NOx emissions below 0.8 g/kW-hr (0.6 g/hp-hr).

Table 1
Samples of Possible Alternative
Emission Standards for Large SI Engines(g/kW-hr)*

	HC+NOx	CO
Duty-cycle testing	2.70	4.4
	2.20	5.6
	1.70	7.9
	1.30	11.1
	1.00	15.5
	0.80	20.6
Field testing	3.80	6.5
	3.10	8.5
	2.40	11.7
	1.80	16.8
	1.40	23.1
	1.10	31.0

*As described in the Final Regulatory Support Document and the regulations, the values in the table are related by the following formula: (HC+NOx) × $CO^{0.784}$ = 8.57. These values follow directly from the logarithmic relationship presented with the proposal in the Draft Regulatory Impact Analysis. The analogous formula for field-testing standards is (HC+NOx) × $CO^{0.791}$ = 16.78.

In addition, Tier 2 engines must have engine diagnostic capabilities that alert the operator to malfunctions in the engine's emission-control system. Gasoline-fueled Tier 2 engines will also be required to reduce evaporative emissions. The field-testing procedures and standards in this final rule make it possible for the manufacturer to easily test engines to meet the requirements of the in-use testing program for showing that engines undergoing several years of normal operation in the field continue to meet emission standards.

Nonroad recreational engines and vehicles

These are spark-ignition nonroad engines used primarily in recreational applications. These include off-highway motorcycles, all-terrain-vehicles (ATVs), and snowmobiles. Some of these engines, particularly those used on ATVs, are increasingly used for commercial purposes within urban areas, especially for hauling loads and other utility purposes. These vehicles are typically used in suburban and rural areas, where they can contribute to ozone formation and ambient CO and PM levels. They can also contribute to regional haze problems in our national and state parks. Tables 2 and 3 show the exhaust and permeation emission standards that apply to recreational vehicles.

Table 2
Recreational Vehicle Exhaust Emission Standards

Vehicle	Model Year	Emission standards		Phase-in
		HC g/kW-hr	CO g/kW-hr	
Snowmobile	2006	100	275	50%
	2007 through 2009	100	275	100%
	2010	75	275	
	2012*	75	200	
		HC+NOx g/km	CO g/km	
Off-highway Motorcycle	2006	2.0	25.0	50%
	2007 and later	2.0	25.0	100%
ATV	2006	1.5	35.0	50%
	2007 and later	1.5	35.0	100

* or equivalent per Section 1051.103; the long term program includes a provision which acts to cap NOx emission rates

Table 3
Permeation Standards for Recreational Vehicles

Emission Component	Implementation Date	Standard	Test Temperature
Fuel Tank Permeation	2008	1.5 $g/m^2/day$	28°C (82°F)
Hose Permeation	2008	15 $g/m^2/day$	23°C (73°F)

Recreational marine diesel engines

These are marine diesel engines used on recreational vessels such as yachts, cruisers, and other types of pleasure craft. Recreational marine engines are primarily used in warm weather and therefore contribute to ozone formation and PM levels, especially in marinas, which are often located in nonattainment areas.

Table 4
Recreational Marine Diesel Emission Limits and Implementation Dates

Displacement [liters per cylinder]	Implementation Date	HC+NOx g/kW-hr	PM g/kW-hr	CO g/kW-hr
power $\geq$ 37 kW 0.5 $\leq$ disp < 0.9	2007	7.5	0.40	5.0
0.9 $\leq$ disp < 1.2	2006	7.2	0.30	5.0
1.2 $\leq$ disp < 2.5	2006	7.2	0.20	5.0
2.5 $\leq$ disp	2009	7.2	0.20	5.0

Projected Impacts

The following paragraphs and tables summarize the projected emission reductions and costs associated with the emission standards. See the detailed analysis later in this document for further discussion of these estimates.

Tables 5 and 6 contain the projected emissions from the engines subject to this action. Projected figures compare the estimated emission levels with and without the emission standards for 2020.

Table 5
2020 HC and NOx Projected Emissions Inventories (thousand short tons)

Category	Exhaust HC*			Exhaust NOx		
	base case	with standards	percent reduction	base case	with standards	percent reduction
Industrial SI >19kW	318	34	89	472	43	91
Snowmobiles	358	149	58	5	10	(101)
ATVs	374	53	86	8	6	25
Off-highway motorcycles	232	117	50	1.3	1.5	(19)
Recreational Marine diesel	2.0	1.5	28	61	48	21
Total	1,284	355	72	547	109	80

* The estimate for Industrial SI >19kW includes both exhaust and evaporative emissions. The estimates for snowmobiles, ATVs and Off-highway motorcycles includes both exhaust and permeation emissions.

Table 6
2020 Projected CO and PM Emissions Inventories (thousand short tons)

Category	Exhaust CO			Exhaust PM		
	base case	with standards	percent reduction	base case	with standards	percent reduction
Industrial SI >19kW	2,336	277	88	2.3	2.3	0
Snowmobiles	950	508	46	8.4	4.9	42
ATVs	1,250	1,085	13	13.1	1.9	86
Off-highway motorcycles	321	236	26	8.7	4.4	50
Recreational Marine diesel	9	9	0	1.6	1.3	18
Total	4,866	2,115	56	34.2	14.8	57

Table 7 summarizes the projected costs to meet the emission standards. This is our best estimate of the cost associated with adopting new technologies to meet the emission standards. The analysis also considers total operating costs, including maintenance and fuel consumption. In many cases, the fuel savings from new technology are greater than the cost to upgrade the engines. All costs are presented in 2001 dollars.

Table 7
Estimated Average Cost Impacts of Emission Standards

Standards	Dates	Increased Production Cost per Vehicle*	Lifetime Operating Costs per Vehicle (NPV)
Large SI exhaust	2004	$611	$-3,981
Large SI exhaust	2007	$55	$0
Large SI evaporative	2007	$13	$-56
Snowmobile exhaust	2006	$73	$-57
Snowmobile exhaust	2010	$131	$-286
Snowmobile exhaust	2012	$89	$-191
Snowmobile permeation	2008	$7	$-11
ATV exhaust	2006	$84	$-24
ATV permeation	2008	$3	$-6
Off-highway motorcycle exhaust	2006	$155	$-48
Off-highway motorcycle permeation	2008	$3	$-5
Recreational marine diesel	2006	$346	—

*The estimated long-term costs decrease by about 35 percent. Costs presented for the Large SI and snowmobile second-phase standards are incremental to the first-phase standards.

We also calculated the cost per ton of emission reductions for the standards. For snowmobiles, this calculation is on the basis of HC plus NOx emissions and CO emissions. For all other engines, we attributed the entire cost of the program to the control of ozone precursor emissions (HC or NOx or both). A separate calculation could apply to reduced CO or PM emissions in some cases. Assigning the full compliance costs to a narrow emissions basis leads to cost-per-ton values that underestimate of the value of the program.

Table 8 presents the discounted cost-per-ton estimates for the various engine categories and standards being adopted. Reduced operating costs more than offset the increased cost of producing the cleaner engines for Large SI and snowmobile engines. The overall fuel savings associated with the standards being adopted are greater than the total projected costs to comply with the emission standards.

Table 8
Estimated Cost-per-Ton of Emission Standards

Standards	Dates	Discounted Reductions per Vehicle (short tons)*	Discounted Cost per Ton of HC+NOx		Discounted Cost per Ton of CO	
			Without Fuel Savings	With Fuel Savings	Without Fuel Savings	With Fuel Savings
Large SI exhaust (Composite of all fuels)	2004	3.07	$240	($1,150)	—	—
Large SI exhaust (Composite of all fuels)	2007	0.80	$80	$80	—	—
Large SI evaporative	2007	0.13	$80	($280)	—	—
Snowmobile exhaust	2006	HC: 0.40 CO: 1.02	$90	$20	$40	$10
Snowmobile exhaust	2010	HC: 0.10	$1,370	$0	—	—
Snowmobile exhaust	2012	CO: 0.25	—	—	$360	$0
Snowmobile permeation	2008	0.03	$210	($150)	—	—
ATV exhaust	2006	0.21	$400	$290	—	—
ATV permeation	2008	0.02	$180	($180)	—	—
Off-highway motorcycle exhaust	2006	0.38	$410	$280	—	—
Off-highway motorcycle permeation	2008	0.01	$230	($140)	—	—
Recreational marine diesel	2006	0.44	$670	$670	—	—
Aggregate	—	—	$240	($280)	$80	($20)

* HC reductions for evaporative and permeation, and HC+NOx reductions for exhaust (except snowmobiles where CO reductions are also presented).

Economic Impact Analysis

We performed an analysis to estimate the economic impacts of this final rule on producers and consumers of recreational marine diesel vessels (specifically, diesel inboard cruisers), forklifts, snowmobiles, ATVs, off-highway motorcycles, and society as a whole. This economic impact analysis focuses on market-level changes in price, quantity, and economic welfare (social gains or costs) associated with the regulation. A description of the methodology used can be found in Chapter 9 of this document.

We did not perform an economic impact analysis for categories of Large SI nonroad engines other than forklifts, even though those other Large SI engines are also subject to the standards contained in this final rule. This was due to the large number of different types of equipment that use Large SI engines and data availability constraints for those market segments. For the sake of completeness, the following analysis reports separate estimates for Large SI engines other than forklifts. Engineering costs are assumed to be equal to economic costs for those engines. This approach slightly overestimates the social costs associated with the relevant standards.

Based on the estimated regulatory costs associated with this rule and the predicted changes in prices and quantity produced in the affected industries, the total estimated annual social gains of the rule in the year 2030 is projected to be $553.3 million (in 2000 and 2001 dollars). The net present value of the social gains for the 2002 to 2030 time frame is equal to $4.9 billion. The social gains are equal to the fuel savings minus the combined loss in consumer and producer surplus (see Table 9), taking into account producers' and consumers' changes in behavior resulting from the costs associated with the rule.[1] Social gains do not account for the social benefits (the monetized health and environmental effects of the rule).

Table 9
Surplus Losses, Fuel Efficiency Gains, and Social Gains/Costs in 2030[a]

Vehicle Category	Surplus Losses in 2030 ($millions)	Fuel Efficiency Gains in 2030 ($millions)	Social Gains/Costs in 2030[b] ($millions)
Recreational marine diesel vessels	$6.6	$0	($6.6)
Forklifts	$47.8	$420.1	$372.3
Other Large SI[c]	$48.1	$138.4	$90.3
Snowmobiles	$41.9	$135.0	$93.1
ATVs	$47.2	$51.4	$4.2
Off-highway motorcycles	$25.0	$25.2	$0.2
All vehicles total	$216.6	$770.1	$553.3
NPV of all vehicles total[d]	$3,231.4	$8,130.3	$4,898.9

[a] Figures are in 2000 and 2001dollars.
[b] Figures in this column exclude estimated social benefits. Numbers in parentheses denote social costs.
[c] Figure is engineering costs; see Section 9.7.6 of Chapter 9 for explanation.
[d] Net Present Value is calculated over the 2002 to 2030 time frame using a 3 percent discount rate.

For most of the engine categories contained in this rule, we expect there will be a fuel savings as manufacturers redesign their engines to comply with emission standards. For ATVs and off-highway motorcycles, the fuel savings will be realized as manufacturers switch from

[1]Consumer and producer surplus losses are measures of the economic welfare loss consumers and producers, respectively are likely to experience as a result of the regulations. Combined these losses represent an estimate of the economic or social costs of the rule. Note that for the Large SI and recreational vehicle rules, fuel efficiency gains must be netted from surplus losses to estimate the social costs or social gains (in cases where fuel efficiency gains exceed surplus losses) attributable to the rules.

two-stroke to four-stroke technologies. For snowmobiles, the fuel savings will be realized as manufacturers switch some of their engines to more fuel efficient two-stroke technologies and some of their engines to four-stroke technologies. For Large SI engines, the fuel savings will be realized as manufacturers adopt more sophisticated and more efficient fuel systems; this is true for all fuels used by Large SI engines. Overall, we project the fuel savings associated with the anticipated changes in technology to be about 800 million gallons per year once the program is fully phased in. These savings are factored into the calculated costs and costs per ton of reduced emissions, as described above.

Chapter 1: Health and Welfare Concerns

The engines and vehicles that would be subject to the standards in this final rule generate emissions of HC, NOx, CO, PM and air toxics. They contribute to ozone and CO nonattainment and to adverse health effects associated with ambient concentrations of PM and air toxics. They also contribute to visibility impairment in Class I areas and in other areas where people live, work, and recreate. This chapter presents our estimates of the contribution these engines make to our national air inventory. We include in this chapter estimates of pre- and post-control contributions. These estimates are described in greater detail in Chapter 6.

This chapter also describes the health and environmental effects related to these emissions. These pollutants cause a range of adverse health and welfare effects, especially in terms of respiratory impairment and related illnesses and visibility impairment both in Class I areas and in areas where people live, work and recreate. Air quality modeling and monitoring data presented in this chapter indicate that a large number of our citizens continue to be affected by these emissions.

1.1 Inventory Contributions

1.1.1 Inventory Contribution

The contribution of emissions from the nonroad engines and vehicles that would be subject to the standards to the national inventories of pollutants that are associated with the health and public welfare effects described in this chapter are considerable. To estimate nonroad engine and vehicle emission contributions, we used the latest version of our NONROAD emissions model. This model computes nationwide, state, and county emission levels for a wide variety of nonroad engines, and uses information on emission rates, operating data, and population to determine annual emission levels of various pollutants. A more detailed description of the model and our estimation methodology can be found in the Chapter 6 of this document.

Baseline emission inventory estimates for the year 2000 for the categories of engines and vehicles covered by this rulemaking are summarized in Table 1.1-1. This table show the relative contributions of the different mobile-source categories to the overall national mobile-source inventory. Of the total emissions from mobile sources, the categories of engines and vehicles covered by this rulemaking contribute about 9 percent, 3 percent, 4 percent, and 2 percent of HC, NOx, CO, and PM emissions, respectively, in the year 2000. The results for large SI engines indicate they contribute approximately 2 to 3 percent to HC, NOx, and CO emissions from mobile sources. The results for land-based recreational engines reflect the impact of the significantly different emissions characteristics of two-stroke engines. These engines are estimated to contribute about 6 percent of HC emissions and 2 percent of CO from mobile sources. Recreational CI marine contribute less than 1 percent to NOx mobile source inventories. When only nonroad emissions are considered, the engines and vehicles that would be subject to the standards would account for a larger share.

Our emission projections for 2020 and 2030 for the nonroad engines and vehicles subject to this rulemaking show that emissions from these categories are expected to increase over time if left uncontrolled. The projections for 2020 and 2030 are summarized in Tables 1.1-2 and 1.1-3, respectively. The projections for 2020 and 2030 indicate that the categories of engines and vehicles covered by this rulemaking are expected to contribute approximately 25 percent, 10 percent, 5 percent, and 5 percent of HC, NOx, CO, and PM emissions, respectively. Population growth and the effects of other regulatory control programs are factored into these projections. The relative importance of uncontrolled nonroad engines is higher than the projections for 2000 because there are already emission control programs in place for the other categories of mobile sources which are expected to reduce their emission levels. The effectiveness of all control programs is offset by the anticipated growth in engine populations.

Table 1.1-1
Modeled Annual Emission Levels for
Mobile-Source Categories in 2000 (thousand short tons)

Category	NOx		HC		CO		PM	
	1000 tons	percent of mobile source	1000 tons	percent of mobile source	1000 tons	percent of mobile source	1000 tons	percent of mobile source
Total for engines subject to today's standards*	**351**	**2.6%**	**645**	**8.8%**	**2,860**	**3.8%**	**14.6**	**2.1%**
Highway Motorcycles	8	0.1%	84	1.2%	331	0.4%	0.4	0.1%
Nonroad Industrial SI > 19 kW*	308	2.3%	226	3.1%	1,734	2.3%	1.6	0.2%
Recreational SI*	5	0.0%	418	5.7%	1,120	1.5%	12.0	1.7%
Recreational Marine CI*	38	0.3%	1	0.0%	6	0.0%	1	0.1%
Marine SI Evap	0	0.0%	100	1.4%	0	0.0%	0	0.0%
Marine SI Exhaust	32	0.2%	708	9.7%	2,144	2.8%	38	5.4%
Nonroad SI < 19 kW	106	0.8%	1,460	20.0%	18,359	24.3%	50	7.1%
Nonroad CI	2,625	19.5%	316	4.3%	1,217	1.6%	253	35.9%
Commercial Marine CI	963	7.2%	30	0.4%	127	0.2%	41	5.8%
Locomotive	1,192	8.9%	47	0.6%	119	0.2%	30	4.3%
Total Nonroad	5,269	39%	3,305	45%	24,826	33%	427	60%
Total Highway	7,981	59%	3,811	52%	49,813	66%	240	34%
Aircraft	178	1%	183	3%	1,017	1%	39	6%
Total Mobile Sources	13,428	100%	7,300	100%	75,656	100%	706	100%
Total Man-Made Sources	24,532	--	18,246	--	97,735	--	3,102	--
Mobile Source percent of Total Man-Made Sources	55%	--	40%	--	77%	--	23%	–

Table 1.1-2
Modeled Annual Emission Levels for
Mobile-Source Categories in 2020 (thousand short tons)

Category	NOx		HC		CO		PM	
	1000 tons	percent of mobile source	1000 tons	percent of mobile source	1000 tons	percent of mobile source	1000 tons	percent of mobile source
Total for engines subject to today's standards*	547	8.8%	1,305	24.1%	4,866	5.6%	34.1	5.2%
Highway Motorcycles	14	0.2%	142	2.6%	572	0.7%	0.8	0.1%
Nonroad Industrial SI > 19 kW*	472	7.6%	318	5.9%	2,336	2.7%	2.3	0.4%
Recreational SI*	14	0.2%	985	18.2%	2,521	2.9%	30.2	4.6%
Recreational Marine CI*	61	1.0%	2	0.0%	9	0.0%	1.6	0.2%
Marine SI Evap	0	0.0%	114	2.1%	0	0.0%	0	0.0%
Marine SI Exhaust	58	0.9%	284	5.2%	1,985	2.3%	28	4.3%
Nonroad SI < 19 kW	106	1.7%	986	18.2%	27,352	31.7%	77	11.8%
Nonroad CI	1,791	28.8%	142	2.6%	1,462	1.7%	261	40.0%
Commercial Marine CI	819	13.2%	35	0.6%	160	0.2%	46	7.0%
Locomotive	611	9.8%	35	0.6%	119	0.1%	21	3.2%
Total Nonroad	3,932	63%	2,901	54%	35,944	42%	467	71%
Total Highway	2,050	33%	2,276	42%	48,906	56%	145	22%
Aircraft	232	4%	238	4%	1,387	2%	43	7%
Total Mobile Sources	6,214	100%	5,415	100%	86,237	100%	655	100%
Total Man-Made Sources	16,190	--	15,475	--	109,905	--	3,039	--
Mobile Source percent of Total Man-Made Sources	38%	--	35%	--	79%	--	22%	–

**Table 1.1-3
Modeled Annual Emission Levels for
Mobile-Source Categories in 2030 (thousand short tons)**

Category	NOx		HC		CO		PM	
	1000 tons	percent of mobile source	1000 tons	percent of mobile source	1000 tons	percent of mobile source	1000 tons	percent of mobile source
Total for engines subject to today's standards*	640	10.0%	1,411	23.5%	5,363	5.4%	36.5	4.8%
Highway Motorcycles	17	0.3%	172	2.9%	693	0.7%	1.0	0.1%
Nonroad Industrial SI > 19 kW*	553	8.6%	371	6.2%	2,703	2.7%	2.7	0.4%
Recreational SI*	15	0.2%	1,038	17.3%	2,649	2.7%	31.9	4.2%
Recreational Marine CI*	72	1.1%	2	0.0%	11	0.0%	1.9	0.3%
Marine SI Evap	0	0.0%	122	2.0%	0	0.0%	0	0.0%
Marine SI Exhaust	64	1.0%	269	4.5%	2,083	2.1%	29	3.8%
Nonroad SI < 19 kW	126	2.0%	1,200	20.0%	32,310	32.4%	93	12.3%
Nonroad CI	1,994	31.0%	158	2.6%	1,727	1.7%	306	40.4%
Commercial Marine CI	1,166	18.1%	52	0.9%	198	0.2%	74	9.8%
Locomotive	531	8.3%	30	0.5%	119	0.1%	18	2.4%
Total Nonroad	4,521	70%	3,242	54%	41,800	42%	557	74%
Total Highway	1,648	26%	2,496	42%	56,303	56%	158	21%
Aircraft	262	4%	262	4%	1,502	2%	43	6%
Total Mobile Sources	6,431	100%	6,000	100%	99,605	100%	758	100%
Total Man-Made Sources	16,639	—	17,020	—	123,983	—	3,319	—
Mobile Source percent of Total Man-Made Sources	39%	—	35%	—	80%	—	23%	–

1.1.2 Baseline Inventory Adjustment

Since we proposed this regulatory program, we revised our baseline inventories for the covered engines to reflect information we received during the comment period. These inventory adjustments are discussed in more detail in Chapter 6, and the changes are reflected in the tables above.

We also revised our national mobile source on-highway and nonroad inventories to reflect additional information and to incorporate routine updates since we finalized our On-Highway Heavy-Duty Engine/Diesel Fuel (HD07) rule. The inventory adjustments to our on-highway and nonroad inventories are of particular importance because the health and visibility results reported in the following sections of this chapter are based on the earlier national mobile source baselines that were used as inputs to the air quality model. We did not perform new health effects and visibility modeling for this rule; instead, we relied on the ozone and PM modeling performed for the HD07 rule. Because our estimates of baseline national mobile source inventories have increased since the HD07 rule, relying on the earlier inventories would underestimate future PM levels that we would expect if we conducted new modeling with the revised inventory inputs. Thus, the health effects and visibility information would underestimate the size of populations living in counties with air quality above certain levels compared to new modeling.

Table 1.1-4 contains a summary of the changes to the on-highway and nonroad inventories since the HD07 rule, and reports the percent change in the inventory for each pollutant. This table shows that the HD07 inventories used in the health and visibility modeling underestimate 2020 direct PM emissions by 0.3 percent for highway engines and 9.4 percent for nonroad engines. The HD07 inventories underestimate 2030 direct PM emissions by 0.1 percent for on-highway and 11.9 percent for nonroad engines. HC and NOx emissions could also affect predicted ambient PM concentrations via secondary formation in the atmosphere.

While the health effects and visibility analyses in the following section may thus underestimate the extent of health effects and visibility impairment we would predict if we were to model the information with our updated inventories, the HD07 analysis still supports our determination that these engines cause or contribute to such health and welfare concerns.

Table 1.1-4
Comparison of Inventory Projections to Projections Used for Air Quality Modeling in the 2007 Highway Heavy-Duty Engine/Diesel Fuel Rule (thousand short tons)

Category	Comparison	NOx	HC	CO	Direct PM
2020 Highway	HD07 Modeling Inventories	2,022	2,019	48,334	143
	Current Estimates	2,050	2,276	48,906	145
	Difference	28	257	572	2
	Difference as a percent of total mobile inventory	0.5%	4.7%	0.7%	0.3%
2020 Nonroad (including aircraft)	HD07 Modeling Inventories	4,040	1,995	33,938	449
	Current Estimates	4,164	3,139	37,331	510
	Difference	124	1,144	3,393	61
	Difference as a percent of total mobile inventory	2.0%	21.1%	3.9%	9.4%
2030 Highway	HD07 Modeling Inventories	2,181	1,624	55,610	157
	Current Estimates	2,496	1,648	56,303	158
	Difference	315	24	693	1
	Difference as a percent of total mobile inventory	4.9%	0.4%	0.7%	0.1%
2030 Nonroad (including aircraft)	HD07 Modeling Inventories	2,228	4,325	39,223	509
	Current Estimates	3,504	4,783	43,302	600
	Difference	1,276	458	4,079	91
	Difference as a percent of total mobile inventory	19.8%	7.6%	4.1%	11.9%

1.1.2 Inventory Impacts on a Per Vehicle Basis

In addition to the general inventory contributions described above, the engines that would be subject to the standards are more potent polluters than their highway counterparts in that they have much higher emissions on a per vehicle basis. This is illustrated in Table 1.1-5, which equates the emissions produced in one hour of operation from the different categories of equipment covered by the rulemaking to the equivalent miles of operation it would take for a car produced today to emit the same amount of emissions.

Table 1.1-5
Per-Vehicle Emissions Comparison

Equipment Category	Emission Comparison	Miles a Current Passenger Car Would Need to Drive to Emit the Same Amount of Pollution as the Equipment Category Emits in One Hour of Operation
Recreational Marine CI	HC+NOx	2,400
Large SI	HC+NOx	1,340
Snowmobiles	HC	24,300
Snowmobiles	CO	1,520
2-Stroke ATVs	HC	6,470
4-Stroke ATVs	HC	290
2-Stroke off-road motorcycles	HC	9,580
4-Stroke off-road motorcycles	HC	430

The per engine emissions are important because they mean that operators of these engines and vehicles, as well as those who work in their vicinity, are exposed to high levels of emissions, many of which are air toxics. These effects are of particular concern for people who operate forklifts in enclosed areas and for snowmobile riders following a lead rider. These effects are described in more detail in the next sections.

1.2 Ozone

1.2.1 General Background

Ground-level ozone, the main ingredient in smog, is formed by complex chemical reactions of volatile organic compounds (VOC) and NOx in the presence of heat and sunlight. Ozone forms readily in the lower atmosphere, usually during hot summer weather. Volatile organic compounds are emitted from a variety of sources, including motor vehicles, chemical plants, refineries, factories, consumer and commercial products, and other industrial sources. Volatile organic compounds also are emitted by natural sources such as vegetation. Oxides of nitrogen are emitted largely from motor vehicles, off-highway equipment, power plants, and other sources of combustion. Hydrocarbons (HC) are a large subset of VOC, and to reduce mobile source VOC levels we set maximum emissions limits for hydrocarbon as well as particulate matter emissions.

The science of ozone formation, transport, and accumulation is complex. Ground-level ozone is produced and destroyed in a cyclical set of chemical reactions involving NOx, VOC, heat, and sunlight.[1] As a result, differences in weather patterns, as well as NOx and VOC levels, contribute to daily, seasonal, and yearly differences in ozone concentrations and differences from city to city. Many of the chemical reactions that are part of the ozone-forming cycle are sensitive to temperature and sunlight. When ambient temperatures and sunlight levels remain high for several days and the air is relatively stagnant, ozone and its precursors can build up, resulting in higher ambient ozone levels than typically would occur on a single high temperature day. Further complicating matters, ozone also can be transported into an area from pollution sources found hundreds of miles upwind, resulting in elevated ozone levels even in areas with low local VOC or NOx emissions.

On the chemical level, NOx and VOC are the principal precursors to ozone formation. The highest levels of ozone are produced when both VOC and NOx emissions are present in significant quantities on clear summer days. Relatively small amounts of NOx enable ozone to form rapidly when VOC levels are relatively high, but ozone production is quickly limited by removal of the NOx. Under these conditions, NOx reductions are highly effective in reducing ozone while VOC reductions have little effect. Such conditions are called "NOx limited." Because the contribution of VOC emissions from biogenic (natural) sources to local ambient ozone concentrations can be significant, even some areas where man-made VOC emissions are relatively low can be NOx limited.

When NOx levels are relatively high and VOC levels relatively low, NOx forms inorganic nitrates but relatively little ozone. Such conditions are called "VOC limited." Under these conditions, VOC reductions are effective in reducing ozone, but NOx reductions can actually increase local ozone under certain circumstances. Even in VOC limited urban areas, NOx reductions are not expected to increase ozone levels if the NOx reductions are sufficiently large.

Rural areas are almost always NOx limited, due to the relatively large amounts of biogenic VOC emissions in such areas. Urban areas can be either VOC or NOx limited, or a mixture of both.

Ozone concentrations in an area also can be lowered by the reaction of nitric oxide with ozone, forming nitrogen dioxide (NO_2); as the air moves downwind and the cycle continues, the NO_2 forms additional ozone. The importance of this reaction depends, in part, on the relative concentrations of NOx, VOC, and ozone, all of which change with time and location.

1.2.2 Health and Welfare Effects of Ozone and Its Precursors

Based on a large number of recent studies, EPA has identified several key health effects caused when people are exposed to levels of ozone found today in many areas of the country.[2, 3] Short-term exposures (1-3 hours) to high ambient ozone concentrations have been linked to increased hospital admissions and emergency room visits for respiratory problems. For example, studies conducted in the northeastern U.S. and Canada show that ozone air pollution is associated with 10-20 percent of all of the summertime respiratory-related hospital admissions. Repeated exposure to ozone can make people more susceptible to respiratory infection and lung inflammation and can aggravate preexisting respiratory diseases, such as asthma. Prolonged (6 to 8 hours), repeated exposure to ozone can cause inflammation of the lung, impairment of lung defense mechanisms, and possibly irreversible changes in lung structure, which over time could lead to premature aging of the lungs and/or chronic respiratory illnesses such as emphysema and chronic bronchitis.

Children and outdoor workers are most at risk from ozone exposure because they typically are active outside during the summer when ozone levels are highest. For example, summer camp studies in the eastern U.S. and southeastern Canada have reported significant reductions in lung function in children who are active outdoors. Further, children are more at risk than adults from ozone exposure because their respiratory systems are still developing. Adults who are outdoors and are moderately active during the summer months, such as construction workers and other outdoor workers, also are among those most at risk. These individuals, as well as people with respiratory illnesses such as asthma, especially asthmatic children, can experience reduced lung function and increased respiratory symptoms, such as chest pain and cough, when exposed to relatively low ozone levels during prolonged periods of moderate exertion.

Evidence also exists of a possible relationship between daily increases in ozone levels and increases in daily mortality levels. While the magnitude of this relationship is too uncertain to allow for direct quantification, the full body of evidence indicates the possibility of a positive relationship between ozone exposure and premature mortality.

In addition to human health effects, ozone adversely affects crop yield, vegetation and forest growth, and the durability of materials. Because ground-level ozone interferes with the ability of a plant to produce and store food, plants become more susceptible to disease, insect attack, harsh weather and other environmental stresses. Ozone causes noticeable foliage damage in many crops, trees, and ornamental plants (i.e., grass, flowers, shrubs) and causes reduced growth in plants. Studies indicate that current ambient levels of ozone are responsible for damage to forests and ecosystems (including habitat for native animal species). Ozone chemically attacks elastomers (natural rubber and certain synthetic polymers), textile fibers and dyes, and, to a lesser extent, paints. For example, elastomers become brittle and crack, and dyes fade after exposure to ozone.

Volatile organic compounds emissions are detrimental not only for their role in forming ozone, but also for their role as air toxics. Some VOCs emitted from motor vehicles are toxic compounds. At elevated concentrations and exposures, human health effects from air toxics can range from respiratory effects to cancer. Other health impacts include neurological developmental and reproductive effects. The toxicologically significant VOCs emitted in substantial quantities from the engines that are the subject of this rule are discussed in more detail in Section 1.6, below.

1.2.3 Ozone Nonattainment and Contribution to Ozone Nonattainment

The current primary and secondary ozone National Ambient Air Quality Standard (NAAQS) is 0.12 ppm daily maximum 1-hour concentration, not to be exceeded more than once per year on average. The determination that an area is at risk of exceeding the ozone standard in the future was made for all areas with current design values grater than or equal to 0.125 ppm (or within a 10 percent margin) and with modeling evidence that exceedances will persist into the future.

Ground level ozone today remains a pervasive pollution problem in the United States. In 1999, 90.8 million people (1990 census) lived in 31 areas designated nonattainment under the 1-hour ozone NAAQS.[4] This sharp decline from the 101 nonattainment areas originally identified under the Clean Air Act Amendments of 1990 demonstrates the effectiveness of the last decade's worth of emission-control programs. However, elevated ozone concentrations remain a serious public health concern throughout the nation.

Over the last decade, declines in ozone levels were found mostly in urban areas, where emissions are heavily influenced by controls on mobile sources and their fuels. Twenty-three metropolitan areas have realized a decline in ozone levels since 1989, but at the same time ozone levels in 11 metropolitan areas with 7 million people have increased.[5] Regionally, California and the Northeast have recorded significant reductions in peak ozone levels, while four other regions (the Mid-Atlantic, the Southeast, the Central and Pacific Northwest) have seen ozone levels increase.

The highest ambient concentrations are currently found in suburban areas, consistent with downwind transport of emissions from urban centers. Concentrations in rural areas have risen to the levels previously found only in cities. Particularly relevant to this rulemaking, ozone levels at 17 of our National Parks have increased, and in 1998, ozone levels in two parks, Shenandoah National Park and the Great Smoky Mountains National Park, were 30 to 40 percent higher than the ozone NAAQS over the last decade.[6]

To estimate future ozone levels, we refer to the modeling performed in conjunction with the final HD07 rule.[7] We performed a series of ozone air quality modeling simulations for nearly the entire Eastern U.S. covering metropolitan areas from Texas to the Northeast.[8] This ozone air quality model was based upon the same modeling system as was used in the Tier 2 passenger vehicle air quality analysis,[9] with the addition of enhanced inventory estimates for 2007 and 2030 based on the state of knowledge at the time the modeling was performed. Emissions from nonroad engines, including the engines subject to this final rule, were included as input to the air quality modeling we describe in this section (as shown in Tables 1.1-2 to 1.1-4 above).

The model simulations were performed for several emission scenarios, and the model outputs were combined with current air quality data to identify areas expected to exceed the ozone NAAQS in 2007, 2020, and 2030.[10] The results of this modeling are contained in Table 1.2-1. Areas presented in Table 1.2-1 exhibit 1997-99 air quality data indicating violations of the

1-hour ozone NAAQS, or are within 10 percent of the standard, are predicted to have exceedance in 2007, 2020, or 2030. An area was considered likely to have future exceedances if exceedances were predicted by the model, and the area is currently violating the 1-hour standard, or is within 10 percent of violating the 1-hour standard. Table 1.2-1 shows that 37 areas with a 1999 population of 91 million people are at risk of exceeding the 1-hour ozone standard in 2007. These estimates include contributions from the engines subject to this rule.[2]

[2]Additional information about the Regulatory Model System for Aerosols and Deposition (REMSAD) and our modeling protocols can be found in our Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, document EPA420-R-00-026, December 2000. Docket No. A-2000-01, Document No. A-II-13. This document is also available at http://www.epa.gov/otaq/disel.htm#documents.

Table 1.2-1
Eastern Metropolitan Areas with Modeled Exceedances of the 1-Hour Ozone Standard in 2007, 2020, or 2030 (Includes all national emission controls through HD07 standards)

MSA or CMSA / State	2007	2020	2030	pop (1999)
Atlanta, GA MSA	x	x	x	3.9
Barnstable-Yarmouth, MA MSA*	x			0.2
Baton Rouge, LA MSA	x	x	x	0.6
Beaumont-Port Arthur, TX MSA	x	x	x	0.4
Benton Harbor, MI MSA*	x	x	x	0.2
Biloxi-Gulfport-Pascagoula, MS MSA*	x	x	x	0.3
Birmingham, AL MSA	x	x	x	0.9
Boston-Worcester-Lawrence, MA CMSA	x	x	x	5.7
Charleston, WV MSA*	x	x		0.3
Charlotte-Gastonia-Rock Hill, NC MSA	x	x	x	1.4
Chicago-Gary-Kenosha, IL CMSA	x	x	x	8.9
Cincinnati-Hamilton, OH-KY-IN CMSA*	x	x	x	1.9
Cleveland-Akron, OH CMSA*	x	x	x	2.9
Detroit-Ann Arbor-Flint, MI CMSA	x	x	x	5.4
Grand Rapids-Muskegon-Holland, MI MSA*	x	x	x	1.1
Hartford, CT MSA	x	x	x	1.1
Houma, LA MSA*	x	x	x	0.2
Houston-Galveston-Brazoria, TX CMSA	x	x	x	4.5
Huntington-Ashland, WV-KY-OH MSA	x	x	x	0.3
Lake Charles, LA MSA*	x		x	0.2
Louisville, KY-IN MSA	x	x	x	1
Macon, GA MSA	x			0.3
Memphis, TN-AR-MS MSA	x	x	x	1.1
Milwaukee-Racine, WI CMSA	x	x	x	1.7
Nashville, TN MSA	x	x	x	1.2
New London-Norwich, CT-RI MSA	x	x	x	0.3
New Orleans, LA MSA*	x	x	x	1.3
New York-Northern NJ-Long Island, NY-NJ-CT-PA CMSA	x	x	x	20.2
Norfolk-Virginia Beach-Newport News, VA-NC MSA*	x		x	1.6
Orlando, FL MSA*	x	x	x	1.5
Pensacola, FL MSA	x			0.4
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD CMSA	x	x	x	6
Providence-Fall River-Warwick,RI-MAMSA*	x	x	x	1.1
Richmond-Petersburg, VA MSA	x	x	x	1
St. Louis, MO-IL MSA	x	x	x	2.6
Tampa-St. Petersburg, FL MSA*	x	x		2.3
Washington-Baltimore	x	x	x	7.4
Total number of areas	37	32	32	
Population	91.2	88.5	87.8	91.4

* These areas have registered 1997-1999 ozone concentrations within 10 percent of standard.

With regard to future ozone levels, our air quality ozone modeling for 2020 predicts exceedances of the 1-hour ozone standard in 32 areas with a total of 89 million people (1999 census; see Table 1.2-1). We expect that the control strategies contained in this rulemaking will further assist state efforts already underway to attain and maintain the 1-hour ozone standard.

The inventories that underlie this predictive modeling for 2020 and 2030 include reductions from all current and committed to federal control programs, including the recently promulgated NOx and PM standards for heavy-duty vehicles and low sulfur diesel fuel (HD07 rule). The geographic scope of these areas at risk of future exceedances underscores the need for additional, nationwide controls of ozone precursors.

It should be noted that this modeling did not attempt to examine the prospect of areas attaining or maintaining the ozone standard with possible future controls (i.e., controls beyond current or committed controls). Therefore, this information should be interpreted as indicating what areas are at risk of ozone violations in 2007, 2020 or 2030 without federal, State, or local measures that may be adopted and implemented in the future. We expect many of these areas to adopt additional emission reduction programs, but we are unable to quantify or rely upon future reductions from additional State or local programs since they have not yet been adopted.

1.2.4 Public Health and Welfare Concerns from Prolonged and Repeated Exposures to Ozone

In addition to the health effects described above, there exists a large body of scientific literature that shows that harmful effects can occur from sustained levels of ozone exposure much lower than 0.125 ppm. Studies of prolonged exposures, those lasting about 7 hours, showed health effects from exposures to ozone concentrations as low as 0.08 ppm. Prolonged and repeated exposures to ozone at these levels are common in areas that do not attain the 1-hour NAAQS, and also occur in areas where ambient concentrations of ozone are in compliance with the 1-hour NAAQS.

Prolonged exposure to levels of ozone below the NAAQS have been reported to cause or be statistically associated with transient pulmonary function responses, transient respiratory symptoms, effects on exercise performance, increased airway responsiveness, increased susceptibility to respiratory infection, increased hospital and emergency room visits, and transient pulmonary respiratory inflamation. Such acute health effects have been observed following prolonged exposures at moderate levels of exertion at concentrations of ozone as low as 0.08 ppm, the lowest concentration tested. The effects are more pronounced as concentrations increase, affecting more subjects or having a greater effect on a given subject in terms of functional changes or symptoms. A detailed summary and discussion of the large body of ozone health effects research may be found in Chapters 6 through 9 (Volume 3) of the 1996 Criteria Document for ozone.[11] Monitoring data indicates that 333 counties in 33 states exceed these levels in 1997-99.[12]

To provide a quantitative estimate of the projected number of people anticipated to reside in areas in which ozone concentrations are predicted to exceed the 8-hour level of 0.08 to 0.12 ppm or higher for multiple days, we performed regional modeling using the variable-grid Urban Airshed Model (UAM-V) for the HD07 rule.[13] UAM-V is a photochemical grid model that numerically simulates the effects of emissions, advection, diffusion, chemistry, and surface removal processes on pollutant concentrations within a 3-dimensional grid. As with the previous modeling analysis, the inventories that underlie this predictive modeling include reductions from all current and committed to control programs, including the HD07 NOx and PM reductions.

This HD07 ozone modeling forecast that 111 million people are predicted to live in areas that areas at risk of exceeding these moderate ozone levels for prolonged periods of time in 2020 after accounting for expected inventory reductions due to controls on light- and heavy-duty on-highway vehicles; that number is expected to increase to 125 million in 2030.[14] Prolonged and repeated ozone concentrations at these levels are common in areas throughout the country. These concentrations are found both in areas that are exceeding, and areas that are not exceeding, the 1-hour ozone standard. Areas with these high concentrations are more widespread than those in nonattainment for that 1-hour ozone standard.

Ozone at these levels can have other welfare effects, with damage to plants and ecosystems being of most concern. Plant damage affects crop yields, forestry production, and ornamentals. The adverse effect of ozone on forests and other natural vegetation can in turn cause damage to associated ecosystems, with additional resulting economic losses. Prolonged ozone concentrations of 0.10 ppm can be phytotoxic to a large number of plant species, and can produce acute injury and reduced crop yield and biomass production. Ozone concentrations within the range of 0.05 to 0.10 ppm have the potential over a longer duration of creating chronic stress on vegetation that can result in reduced plant growth and yield, shifts in competitive advantages in mixed populations, decreased vigor, and injury. Ozone effects on vegetation are presented in more detail in Chapter 5, Volume II of the 1996 Criteria Document.

1.2.5 Additional Health and Welfare Effects of NOx Emissions

In addition to their role as an ozone precursor, NOx emissions are associated with a wide variety of other health and welfare effects.[15, 16] Nitrogen dioxide can irritate the lungs and reduce resistance to respiratory infection (such as influenza). Nitrogen dioxide and airborne nitrate also contribute to pollutant haze, which impairs visibility and can reduce residential property values and the value placed on scenic views. Elevated levels of nitrates in drinking water pose significant health risks, especially to infants. NOx emissions are an important precursor to acid rain that may affect both terrestrial and aquatic ecosystems. Atmospheric deposition of nitrogen leads to excess nutrient enrichment problems (“eutrophication”). Deposition of nitrogen-containing compounds also affects terrestrial ecosystems.

1.2.3.1 Acid Deposition

Acid deposition, or acid rain as it is commonly known, occurs when SO_2 and NOx react in the atmosphere with water, oxygen, and oxidants to form various acidic compounds that later fall to earth in the form of precipitation or dry deposition of acidic particles.[17] It contributes to damage of trees at high elevations and in extreme cases may cause lakes and streams to become so acidic that they cannot support aquatic life. In addition, acid deposition accelerates the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage. To reduce damage to automotive paint caused by acid rain and acidic dry deposition, some manufacturers use acid-resistant paints, at an average cost of $5 per vehicle--a total of $61 million per year if applied to all new cars and trucks sold in the U.S.

Acid deposition primarily affects bodies of water that rest atop soil with a limited ability to neutralize acidic compounds. The National Surface Water Survey (NSWS) investigated the effects of acidic deposition in over 1,000 lakes larger than 10 acres and in thousands of miles of streams. It found that acid deposition was the primary cause of acidity in 75 percent of the acidic lakes and about 50 percent of the acidic streams, and that the areas most sensitive to acid rain were the Adirondacks, the mid-Appalachian highlands, the upper Midwest and the high elevation West. The NSWS found that approximately 580 streams in the Mid-Atlantic Coastal Plain are acidic primarily due to acidic deposition. Hundreds of the lakes in the Adirondacks surveyed in the NSWS have acidity levels incompatible with the survival of sensitive fish species. Many of the over 1,350 acidic streams in the Mid-Atlantic Highlands (mid-Appalachia) region have already experienced trout losses due to increased stream acidity. Emissions from U.S. sources contribute to acidic deposition in eastern Canada, where the Canadian government has estimated that 14,000 lakes are acidic. Acid deposition also has been implicated in contributing to degradation of high-elevation spruce forests that populate the ridges of the Appalachian Mountains from Maine to Georgia. This area includes national parks such as the Shenandoah and Great Smoky Mountain National Parks.

1.2.3.2 Eutrophication and Nitrification

Nitrogen deposition into bodies of water can cause problems beyond those associated with acid rain. The Ecological Society of America has included discussion of the contribution of air emissions to increasing nitrogen levels in surface waters in a recent major review of causes and consequences of human alteration of the global nitrogen cycle in its Issues in Ecology series.[18] Long-term monitoring in the United States, Europe, and other developed regions of the world shows a substantial rise of nitrogen levels in surface waters, which are highly correlated with human-generated inputs of nitrogen to their watersheds. These nitrogen inputs are dominated by fertilizers and atmospheric deposition.

Human activity can increase the flow of nutrients into those waters and result in excess algae and plant growth. This increased growth can cause numerous adverse ecological effects and economic impacts, including nuisance algal blooms, dieback of underwater plants due to reduced light penetration, and toxic plankton blooms. Algal and plankton blooms can also reduce the level of dissolved oxygen, which can also adversely affect fish and shellfish populations. This problem is of particular concern in coastal areas with poor or stratified circulation patterns, such as the Chesapeake Bay, Long Island Sound, or the Gulf of Mexico. In such areas, the "overproduced" algae tends to sink to the bottom and decay, using all or most of the available oxygen and thereby reducing or eliminating populations of bottom-feeder fish and shellfish, distorting the normal population balance between different aquatic organisms, and in extreme cases causing dramatic fish kills.

Collectively, these effects are referred to as eutrophication, which the National Research Council recently identified as the most serious pollution problem facing the estuarine waters of the United States.[19] Nitrogen is the primary cause of eutrophication in most coastal waters and estuaries.[20] On the New England coast, for example, the number of red and brown tides and shellfish problems from nuisance and toxic plankton blooms have increased over the past two decades, a development thought to be linked to increased nitrogen loadings in coastal waters. We believe that airborne NOx contributes from 12 to 44 percent of the total nitrogen loadings to United States coastal water bodies. For example, some estimates assert that approximately one-quarter of the nitrogen in the Chesapeake Bay comes from atmospheric deposition.

Excessive fertilization with nitrogen-containing compounds can also affect terrestrial ecosystems.[21] Research suggests that nitrogen fertilization can alter growth patterns and change the balance of species in an ecosystem, providing beneficial nutrients to plant growth in areas that do not suffer from nitrogen over-saturation. In extreme cases, this process can result in nitrogen saturation when additions of nitrogen to soil over time exceed the capacity of the plants and microorganisms to utilize and retain the nitrogen. This phenomenon has already occurred in some areas of the U.S.

1.3 Carbon Monoxide

1.3.1 General Background

Unlike many gases, CO is odorless, colorless, tasteless, and nonirritating. Carbon monoxide results from incomplete combustion of fuel and is emitted directly from vehicle tailpipes. Incomplete combustion is most likely to occur at low air-to-fuel ratios in the engine. These conditions are common during vehicle starting when air supply is restricted ("choked"), when vehicles are not tuned properly, and at high altitude, where "thin" air effectively reduces the amount of oxygen available for combustion (except in engines that are designed or adjusted to compensate for altitude). Carbon monoxide emissions increase dramatically in cold weather. This is because engines need more fuel to start at cold temperatures and because some emission control devices (such as oxygen sensors and catalytic converters) operate less efficiently when they are cold. Also, nighttime inversion conditions are more frequent in the colder months of the year. This is due to the enhanced stability in the atmospheric boundary layer, which inhibits vertical mixing of emissions from the surface.

1.3.2 Health Effects of CO

Carbon monoxide enters the bloodstream through the lungs and forms carboxyhemoglobin (COHb), a compound that inhibits the blood's capacity to carry oxygen to organs and tissues.[22] Carbon monoxide has long been known to have substantial adverse effects on human health, including toxic effects on blood and tissues, and effects on organ functions. Although there are effective compensatory increases in blood flow to the brain, at some concentrations of COHb somewhere above 20 percent these compensations fail to maintain sufficient oxygen delivery, and metabolism declines[23]. The subsequent hypoxia in brain tissue then produces behavioral effects, including decrements in continuous performance and reaction time.[24]

Carbon monoxide has been linked to increased risk for people with heart disease, reduced visual perception, cognitive functions and aerobic capacity, and possible fetal effects. Persons with heart disease are especially sensitive to carbon monoxide poisoning and may experience chest pain if they breathe the gas while exercising. In Ontario, 18 deaths of snowmobilers involved myocardial infarction and 14 involved sudden cardiac death[25]. It is unknown if these deaths are linked to CO exposures.

Infants, elderly persons, and individuals with respiratory diseases are also particularly sensitive. Carbon monoxide can affect healthy individuals, impairing exercise capacity, visual perception, manual dexterity, learning functions, and ability to perform complex tasks. More importantly to many individuals is the frequent exposure of individuals to exhaust emissions from engines operating indoors. The Occupational Safety and Health Administration sets standards regulating the concentration of indoor pollutants, but high local CO levels are still commonplace.

Several recent epidemiological studies have shown a link between CO and premature morbidity (including angina, congestive heart failure, and other cardiovascular diseases). Several studies in the United States and Canada have also reported an association of ambient CO exposures with frequency of cardiovascular hospital admissions, especially for congestive heart failure (CHF). An association of ambient CO exposure with mortality has also been reported in epidemiological studies, though not as consistently or specifically as with CHF admissions. EPA reviewed these studies as part of the Criteria Document review process.[26] There is emerging evidence suggesting that CO is linked with asthma exacerbations.

1.3.3 CO Nonattainment

The current primary NAAQS for CO are 35 parts per million for the one-hour average and 9 parts per million for the eight-hour average. These values are not to be exceeded more than once per year. Air quality carbon monoxide value is estimated using EPA guidance for calculating design values. Over 22.4 million people currently live in the 13 non-attainment areas for the CO NAAQS.[27] As described in Section 1.1, the engines subject to this rule currently account for about 3.8 percent of the mobile source CO inventory; this is expected to increase to 8.8 percent by 2020 without the emission controls in this action.

Emissions from the engines and vehicles covered by this rule contribute to the national CO inventory and to CO levels in several nonattainment areas. Large SI engines are used in forklifts and many types of construction, industrial, and lawn care equipment that are used in urban areas, including nonattainment areas.

ATVs and off-highway motorcycles are also used in counties and cities within CO-nonattainment areas, and are operated on private land and in and around non-attainment areas. This is illustrated by information about ATV use provided by Honda in public comments, which included recent warranty claims for ATVs in three serious CO non-attainment areas: Fairbanks, AK, in 1998 and 2001, in Phoenix, AZ in 2001, and in Las Vegas, NV in 2000.[28] In our December 7, 2000 notice finding that recreational vehicles cause or contribute to CO nonattainment, we provided information showing CO emissions in six nonattainment areas in 2000. Five of these areas remain in nonattainment.

In addition, Western state studies of off-highway vehicle use in Colorado and Utah both indicate that ATVs and off-highway motorcycles are operated on private land about 20 to 30 percent of the time (22.4 percent for off-highway motorcycles and 27.8 percent for ATVs in Utah, and combined vehicles 22.4 percent of off-highway vehicles are operated on the survey respondent's own private land or ranch).[29] In addition, operation of these vehicles is not limited to established trails. Half of the off-highway motorcyclists and 40 percent of the ATV owners in Utah reported riding off established trails or roads.[30] Furthermore, according to the U.S. Consumer Product Safety Commission, almost three quarters of ATV drivers use ATVs for at least one non-recreational activity; half use ATVs for farming or ranching; 63 percent use ATVs for household chores (e.g., yard work); and about 8 percent use ATVs for occupational or commercial tasks.[31] Another CO nonattainment area, Anchorage, AK, estimates ATVs and motorcycles (on- and off-road) contribute 0.19 tons per day in 2000.[32]

Several states that contain CO nonattainment areas also have large populations of registered off-highway motorcycles, as shown in Table 1.3-1 (similar information was not available for ATVs).

Table 1.3-1
Off-Highway Motorcycle Use in Selected CO Nonattainment Areas

City and State	CO Nonattainment Classification	2001 State off-highway motorcycle population[a]
Anchorage, AK	Serious	5,100[b]
Fairbanks, AK	Serious	
Las Vegas, NV	Serious	15,800
Los Angeles, CA	Serious	175,100
Phoenix, AZ	Serious	20,400
Spokane, WA	Serious	44,800
New York/New Jersey/Long Island, NY, NJ, CT	Moderate > 12.7 ppm	81,300
Provo, UT	Moderate > 12.7 ppm	16,600
El Paso, TX	Moderate	61,600
Fort Collins, CO	Moderate	30,200
Medford, OR	Moderate	28,800
Missoula, MT	Moderate	96,00
Reno, NV	Moderate	15,800[b]

[a] Source: Motorcycle Industry Council, 2001 Motorcycle Statistical Annual, Docket A-2000-01, Document No. II-G.
[b] State has more than one CO nonattainment area.

Snowmobiles, which have relatively high per engine CO emissions, can also be an important source of ambient CO levels in CO nonattainment areas. While some of these areas have experienced improved CO air quality in recent years, an area cannot be redesignated to attainment until it can show EPA that it has had air quality levels within the level required for attainment and that it has a plan in place to maintain such levels. Until areas have been redesignated, they remain non-attainment areas.[33] Snowmobiles contribute to CO nonattainment in more than one of these areas.

The state of Alaska estimated (and a National Research Council study confirmed) that snowmobiles contributed 0.3 tons/day in 2001 to Fairbanks' CO nonattainment area or 1.2 percent of a total inventory of 23.3 tons per day in 2001.[3, 4] There is some indication that

[3] Draft Anchorage Carbon Monoxide Emission Inventory and Year 2000 Attainment Projections, Air Quality Program, May 2001, Docket Number A-2000-01, Document II-A-40; Draft Fairbanks 1995-2001 Carbon Monoxide Emissions Inventory, June 1, 2001, Docket

Fairbanks' snowmobile population is significantly higher than EPA's estimates.[34] While Fairbanks has made significant progress in reducing ambient CO concentrations, existing climate conditions make achieving and maintaining attainment challenging. Anchorage, AK, reports a similar contribution of snowmobiles to their emissions inventories (0.34 tons per day in 2000). Furthermore, a recent National Academy of Sciences report concludes that "Fairbanks will be susceptible to violating the CO health standards for many years because of its severe meteorological conditions. That point is underscored by a December 2001 exceedance of the standard in Anchorage which had no violations over the last 3 years."[5] There is also a snowmobile trail within the Spokane, WA, CO nonattainment area.

Several states that contain CO nonattainment areas also have large populations of registered snowmobiles. This is shown in Table 1.3-2. A review of snowmobile trail maps and public comments indicate that snowmobiles are used in counties containing these CO nonattainment areas or in adjoining counties.[35] These include the Mt. Spokane and Riverside trails near the Spokane, Washington, CO nonattainment area; the Larimer trails near the Fort Collins, Colorado CO nonattainment area; and the Hyatt Lake, Lake of the Woods, and Cold Springs trails near the Klamath Falls and Medford, Oregon CO nonattainment area. There are also trails in Missoula County, Montana that demonstrate snowmobile use in the Missoula, Montana CO nonattainment area. While Colorado has a large snowmobile population, the snowmobile trails are fairly distant from the Colorado Springs CO nonattainment area.[36]

Number A-2000-01, Document II-A-39.

[4]National Research Council. The Ongoing Challenge of Managing Carbon Monoxide Pollution in Fairbanks, AK. May 2002. Docket A-2000-01, Document No. IV-A-115.

[5]National Research Council. The Ongoing Challenge of Managing Carbon Monoxide Pollution in Fairbanks, AK. May 2002. Docket A-2000-01, Document IV-A-115.

Table 1.3-2
Snowmobile Use in Selected CO Nonattainment Areas

City and State	CO Nonattainment Classification	2001 State snowmobile population*
Anchorage, AK	Serious	35,576
Fairbanks, AK	Serious	
Spokane, WA	Serious	31,532
Fort Collins, CO	Moderate	32,500
Medford, OR	Moderate	16,809
Missoula, MT	Moderate	23,440

* Source: Letter from International Snowmobile Manufacturers Association to US-EPA, March 14, 2002, Docket A-2000-01, Document No. II-G

While snowmobile trails are often located in rural areas and many are located outside CO nonattainment areas, it is nevertheless the case that snowmobiles are used in urban areas within nonattainment areas. In some northeast cities, "snowmobiles are a common sight in downtown areas [and] are driven in large numbers along streets and recreational paths ... in close proximity to pedestrians, motorists, and those using public parks such as cross-country skiers."[37] A search of the available literature indicates that snowmobiles are ridden in areas other than trails. For example, a report by the Michigan Department of Natural Resources indicates that from 1993 to 1997, of the 146 snowmobile fatalities studied, 46 percent occurred on a state or county roadway (another 2 percent on roadway shoulders) and 27 percent occurred on private lands.[38] Furthermore, accident reports in the CO nonattainment area Fairbanks, AK, document that snowmobiles driven on streets have collided with motor vehicles.[39] On certain days there may be concentrations of snowmobiles operated in non-attainment areas due to public events such as snowmachine races (such as the Iron Dog Gold Rush Classic, which finishes in Fairbanks, AK), during which snowmobiles will be present and operated. There is some indication that Fairbanks snowmobile population is significantly higher than EPA's estimates.[40]

While the operation of snowmobiles alone in an area would not necessarily result in CO nonattainment, emissions from regulated categories need only contribute to, not themselves cause, nonattainment. Concentrations of NAAQS-related pollutants are by definition a result of multiple sources of pollution. The above discussion shows that snowmobiles are operated on snowmobile trails and some are within CO nonattainment areas (e.g., Spokane). Snowmobiles are also used for maintenance operations and other uses in CO nonattainment areas (e.g., Fairbanks and Anchorage), and there is evidence that snowmobiles are operated in town along streets in these and other CO nonattainment areas.

While CO air quality is improving in several northern areas, further reductions may still be required. Exceedances of the 8-hour CO standard were recorded in three of the six CO nonattainment areas located in the northern portion of the country over the five year period from 1994 to 1999: Fairbanks, AK; Medford, OR; and Spokane, WA.[41] Given the variability in CO ambient concentrations due to weather patterns such as inversions, the absence of recent exceedances for some of these nonattainment areas should not be viewed as eliminating the need for further reductions to consistently attain and maintain the standard. A review of CO monitor data in Fairbanks from 1986 to 1995 shows that while median concentrations have declined steadily, unusual combinations of weather and emissions have resulted in elevated ambient CO concentrations well above the 8-hour standard of 9 ppm. Specifically, a Fairbanks monitor recorded average 8-hour ambient concentrations at 16 ppm in 1988, around 9 ppm from 1990 to 1992, and then a steady increase in CO ambient concentrations at 12, 14 and 16 ppm during some extreme cases in 1993, 1994 and 1995, respectively.[42] Furthermore, a recent National Academy of Sciences report concludes that “Fairbanks will be susceptible to violating the CO health standards for many years because of its severe meteorological conditions. That point is underscored by a December 2001 exceedance of the standard in Anchorage which had no violations over the last 3 years.”[43] Fairbanks is located in a mountain valley with a much higher potential for air stagnation than cities within the contiguous United States. Nocturnal inversions that give rise to elevated CO concentrations can persist 24-hours a day due to the low solar elevation, particularly in December and January. These inversions typically last from 2 to 4 days, and thus inversions may continue during hours of maximum CO emissions from mobile sources. While Fairbanks has made significant progress in reducing ambient CO concentrations, existing climate conditions make achieving and maintaining attainment challenging.

In addition to the CO nonattainment areas, there are 6 areas that have not been classified as non-attainment where air quality monitoring indicated a need for CO control. For example, CO monitors in northern locations such as Des Moines, IA, and Weirton, WV/Steubenville, OH, registered levels above the level of the CO standards in 1998.[44]

1.4 Particulate Matter

1.4.1 General Background

Particulate pollution is a problem affecting urban and non-urban localities in all regions of the United States. Nonroad engines and vehicles that would be subject to the standards contribute to ambient particulate matter (PM) levels in two ways. First, they contribute through direct emissions of particulate matter. Second, they contribute to indirect formation of PM through their emissions of organic carbon, especially HC. As shown in Table 1.4-1, organic carbon accounts for between 27 and 36 percent of ambient fine particle mass depending on the area of the country.

Table 1.4-1
Percent Contribution to $PM_{2.5}$ by Component, 1998

	East	West
Sulfate	56	33
Elemental Carbon	5	6
Organic Carbon	27	36
Nitrate	5	8
Crustal Material	7	17

Source: National Air Quality and Emissions Trends Report, 1998, March, 2000, at 28. This document is available at http://www.epa.gov/oar/aqtrnd98/. Relevant pages of this report can be found in Memorandum to Air Docket A-2000-01 from Jean Marie Revelt, September 5, 2001, Document No. II-A-63.

PM represents a broad class of chemically and physically diverse substances. It can be principally characterized as discrete particles that exist in the condensed (liquid or solid) phase spanning several orders of magnitude in size. All particles equal to and less than 10 microns are called PM_{10}. Fine particles can be generally defined as those particles with an aerodynamic diameter of 2.5 microns or less (also known as $PM_{2.5}$), and coarse fraction particles are those particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns.

Manmade emissions that contribute to airborne particulate matter result principally from combustion sources (stationary and mobile sources) and fugitive emissions from industrial processes and non-industrial processes (such as roadway dust from paved and unpaved roads, wind erosion from crop land, construction, etc.). Human-generated sources of particles include a variety of stationary sources (including power generating plants, industrial operations, manufacturing plants, waste disposal) and mobile sources (light- and heavy-duty on-road vehicles, and off-highway vehicles such as construction, farming, industrial, locomotives, marine vessels and other sources). Natural sources also contribute to particulate matter in the atmosphere and include sources such as wind erosion of geological material, sea spray, volcanic emissions, biogenic emanation (e.g., pollen from plants, fungal spores), and wild fires.

The chemical and physical properties of PM vary greatly with time, region, meteorology, and source category. Particles may be emitted directly to the atmosphere (primary particles) or may be formed by transformations of gaseous emissions of sulfur dioxide, nitrogen oxides or volatile organic compounds (secondary particles). Secondary PM is dominated by sulfate in the eastern U.S. and nitrate in the western U.S.[45] The vast majority (>90 percent) of the direct mobile source PM emissions and their secondary formation products are in the fine PM size range. Mobile sources can reasonably be estimated to contribute to ambient secondary nitrate and sulfate PM in proportion to their contribution to total NOx and SOx emissions.

1.4.2 Health and Welfare Effects of PM

Particulate matter can adversely affect human health and welfare. Discussions of the health and welfare effects associated with ambient PM can be found in the Air Quality Criteria for Particulate Matter.[46]

Key EPA findings regarding the health risks posed by ambient PM are summarized as follows:

a. Health risks posed by inhaled particles are affected both by the penetration and deposition of particles in the various regions of the respiratory tract, and by the biological responses to these deposited materials.

b. The risks of adverse effects associated with deposition of ambient particles in the thorax (tracheobronchial and alveolar regions of the respiratory tract) are markedly greater than for deposition in the extrathoracic (head) region. Maximum particle penetration to the thoracic regions occurs during oronasal or mouth breathing.

c. Published, peer-reviewed studies have reported statistical associations between PM and several key health effects, including premature death; aggravation of respiratory and cardiovascular disease, as indicated by increased hospital admissions and emergency room visits, school absences, work loss days, and restricted activity days; changes in lung function and increased respiratory symptoms; changes to lung tissues and structure; and altered respiratory defense mechanisms. Most of these effects have been consistently associated with ambient PM concentrations, which have been used as a measure of population exposure, in a large number of community epidemiological studies. Additional information and insights on these effects are provided by studies of animal toxicology and controlled human exposures to various constituents of PM conducted at higher than ambient concentrations. Although mechanisms by which particles cause effects are not well known, there is general agreement that the cardio-respiratory system is the major target of PM effects.

d. Based on a qualitative assessment of the epidemiological evidence of effects associated with PM for populations that appear to be at greatest risk with respect to particular health endpoints, we have concluded the following with respect to sensitive populations:

    1. Individuals with respiratory disease (e.g., chronic obstructive pulmonary disease, acute bronchitis) and cardiovascular disease (e.g., ischemic heart disease) are at greater risk of premature mortality and hospitalization due to exposure to ambient PM.

    2. Individuals with infectious respiratory disease (e.g., pneumonia) are at greater risk of premature mortality and morbidity (e.g., hospitalization, aggravation of respiratory symptoms) due to exposure to ambient PM. Also, exposure to PM may increase individuals' susceptibility to respiratory infections.

3. Elderly individuals are also at greater risk of premature mortality and hospitalization for cardiopulmonary problems due to exposure to ambient PM.

4. Children are at greater risk of increased respiratory symptoms and decreased lung function due to exposure to ambient PM.

5. Asthmatic individuals are at risk of exacerbation of symptoms associated with asthma, and increased need for medical attention, due to exposure to PM.

e. There are fundamental physical and chemical differences between fine and coarse fraction particles. The fine fraction contains acid aerosols, sulfates, nitrates, transition metals, diesel exhaust particles, and ultra fine particles; the coarse fraction typically contains high mineral concentrations, silica and resuspended dust. It is reasonable to expect that differences may exist in both the nature of potential effects elicited by coarse and fine PM and the relative concentrations required to produce such effects. Both fine and coarse particles can accumulate in the respiratory system. Exposure to coarse fraction particles is primarily associated with the aggravation of respiratory conditions such as asthma. Fine particles are closely associated with health effects such as premature death or hospital admissions, and for cardiopulmonary diseases.

With respect to welfare or secondary effects, fine particles have been clearly associated with the impairment of visibility over urban areas and large multi-State regions. Particles also contribute to soiling and materials damage. Components of particulate matter (e.g., sulfuric or nitric acid) also contribute to acid deposition, nitrification of surface soils and water eutrophication of surface water.

1.4.3 PM Nonattainment

1.4.3.1 PM_{10} Concentrations and Nonattainment

The NAAQS for PM_{10} was established in 1987. According to these standards, the short term (24-hour) standard of 150 $\mu g/m^3$ is not to be exceeded more than once per year on average over three years. The long-term standard specifies an expected annual arithmetic mean not to exceed 50 $\mu g/m^3$ over three years.

PM_{10} monitoring data indicate that 14 designated PM_{10} nonattainment areas with a projected population of 23 million violated the PM_{10} NAAQS in the period 1997-1999. Table 1.4-2 lists the 14 areas, and also indicates the PM_{10} nonattainment classification, and 1999 projected population for each PM_{10} nonattainment area. The projected population in 1999 was based on 1990 population figures which were then increased by the amount of population growth in the county from 1990 to 1999.

Table 1.4-2
PM_{10} Nonattainment Areas Violating the PM_{10} NAAQS in 1997-1999

Nonattainment Area or County	1999 Population (projected, in thousands)
Anthony, NM (Moderate)[b]	3
Clark Co [Las Vegas], NV (Serious)	1,200
Coachella Valley, CA (Serious)	239
El Paso Co, TX (Moderate)[a]	611
Hayden/Miami, AZ (Moderate)	4
Imperial Valley, CA (Moderate)	122
Los Angeles South Coast Air Basin, CA (Serious)	14,352
Nogales, AZ (Moderate)	25
Owens Valley, CA (Serious)	18
Phoenix, AZ (Serious)	2,977
San Joaquin Valley, CA (Serious)	3,214
Searles Valley, CA (Moderate)	29
Wallula, WA (Moderate)[b]	52
Washoe Co [Reno], NV (Moderate)	320
Total Areas: 14	23,167

[a] EPA has determined that continuing PM_{10} nonattainment in El Paso, TX is attributable to transport under section 179(B).

[b] The violation in this area has been determined to be attributable to natural events under section 188(f) of the Act.

In addition to the 14 PM_{10} nonattainment areas that are currently violating the PM_{10} NAAQS listed in Table 1.4-2, there are 25 unclassifiable areas that have recently recorded ambient concentrations of PM_{10} above the PM_{10} NAAQS. EPA adopted a policy in 1996 that allows areas with PM_{10} exceedances that are attributable to natural events to retain their designation as unclassifiable if the State is taking all reasonable measures to safeguard public health regardless of the sources of PM_{10} emissions. Areas that remain unclassifiable areas are not required under the Clean Air Act to submit attainment plans, but we work with each of these areas to understand the nature of the PM_{10} problem and to determine what best can be done to reduce it. With respect to the monitored violations reported in 1997-99 in the 25 areas designated as unclassifiable, we have not yet excluded the possibility that factors such as a one-time monitoring upset or natural events, which ordinarily would not result in an area being designated as nonattainment for PM_{10}, may be responsible for the problem. Emission reductions from today's action will assist these currently unclassifiable areas to achieve ambient PM_{10} concentrations below the current PM_{10} NAAQS.

1.4.3.2 $PM_{2.5}$ Concentrations

Fine particle concentrations contribute to both health effects and visibility impairment. This section presents our assessment of current and future PM2.5 levels. Because monitoring data are not available for all areas, we have modeled PM2.5 levels for those areas using the EPA's Regulatory Model System for Aerosols and Deposition (REMSAD) model. These concentrations are related to both health effects and visibility impairment. After a brief description of the PM air quality model, we present current PM2.5 data, both modeled and estimated. Then we present projections of PM2.5 levels that were estimated using REMSAD.

1.4.3.2.1 Description of PM Air Quality Modeling

To estimate both current PM2.5 levels in areas for which no monitoring data are available and future $PM_{2.5}$ levels for all areas, we refer to the PM air quality modeling performed in conjunction with EPA's on-highway Heavy Duty Engine/Diesel Fuel (HD07) final rule. This modeling was performed using EPA's Regulatory Model System for Aerosols and Deposition (REMSAD) model.[47] We describe the REMSAD modeling because we use the modeling examine visibility impairment and population exposures related to the PM health effects we would anticipate would occur without the emissions reductions from this rulemaking. The REMSAD modeling was also a key input for the economic benefits transfer technique described in Chapter 10 related to selected PM health effects.

REMSAD simulates every hour of every day of the year and, thus, requires a variety of input files that contain information pertaining to the modeling domain and simulation period. These include gridded, 3-hour average emissions estimates and meteorological fields, initial and boundary conditions, and land-use information. As applied to the contiguous U.S., the model segments the area within the region into square blocks called grids (roughly equal in size to counties), each of which has several layers of air conditions. Using this data, REMSAD generates predictions of 3-hour average PM concentrations for every grid. We then calculated daily and seasonal PM air quality metrics.

REMSAD was peer-reviewed in 1999 for EPA as reported in "*Scientific Peer-Review of the Regulatory Modeling System for Aerosols and Deposition.*" Earlier versions of REMSAD have been employed for the EPA's Prospective CAA Section 812 Report to Congress and for EPA's Analysis of the Acid Deposition and Ozone Control Act (Senate Bill 172). Version 4.1 of REMSAD was employed for the HD07 final rule analysis and is fully described in the air quality technical support documents for that HD07 rulemaking. We focus on the HD07 modeling because it is the most current modeling for mobile sources.

For the HD07 rulemaking, EPA modeled PM air quality in 1996 and in 2030 after those requirements were to take effect using REMSAD. Although we did not undertake new air quality modeling for this rulemaking, the modeling from the HD07 rulemaking can be considered a baseline for this rulemaking. As explained in Section 1.1.2, the emissions inventories that were used in the HD07 REMSAD modeling have been updated and that the HD07 modeling may underestimate the PM2.5 levels that we would expect with revised emissions inventories.

1.4.3.2.2 Current PM Air Quality

The 1999-2000 $PM_{2.5}$ monitored values, which cover about a third of the nation's counties, indicate that at least 82 million people live in areas where long-term ambient fine particulate matter levels are at or above 15 µg/m^3.[48]

To estimate the current number of people who live in areas where long-term ambient fine particulate matter levels are at or above 16 µg/m^3 but for which there are no monitors, we can use the HD07 REMSAD modeling described above. At the time the HD07 modeling was performed, 1999 PM monitoring data were not yet available, so we conducted 1996 base year modeling to reproduce the atmospheric processes resulting in formation and dispersion of $PM_{2.5}$ across the U.S. and to evaluate operational model performance for $PM_{2.5}$ and its related speciated components (e.g., sulfate, nitrate, elemental carbon) which are important to visibility impairment. This 1996 modeling included emissions from the engines subject to this final rule (although earlier emissions estimates were used). According to our national modeled predictions, there were a total of 76 million people (1996 population) living in areas with modeled annual average $PM_{2.5}$ concentrations at or above 16 µg/m^3 (29 percent of the population).[49]

1.4.3.2.3 Future PM Air Quality

To estimate future year concentrations, we can use the air quality model to predict changes between current and future states. The most reliable information would be to compare future levels in counties for which we have monitoring data. Thus, we estimated future conditions for the areas with current $PM_{2.5}$ monitored data (which covered about a third of the nation's counties at that time).[50] For these counties, REMSAD predicts the current level of 37 percent of the population living in areas where fine PM levels above 15 µg/m3 to increase to 49 percent in 2030.[51] Again, this 2030 modeling included emissions from the engines subject to this final rule (although earlier emissions estimates were used). These emissions are contributing to air quality levels that may result in future PM nonattainment. Nonattainment status is related to both health impacts described above and welfare impacts, such as visibility impairment, soiling, and material damage. Thus, for areas with levels above the NAAQS, unacceptable health and welfare effects are anticipated to be occurring, and emissions from the engines subject to this rulemaking are contributing to these anticipated adverse effects. In Table 1.4-3, we summarize the national PM air quality based on the HD07 REMSAD modeling.

Table 1.4-3
Summary of Anticipated 2030 National PM Baseline Air Quality (μg/m³)

Statistic	2030 Air Quality Value (μg/m³)[a]
PM_{10}	
Minimum Annual Mean[b]	1.49
Maximum Annual Mean[b]	64.29
Average Annual Mean	10.03
Median Annual Mean	7.97
Population-Weighted Average Annual Mean[c]	21.04
$PM_{2.5}$	
Minimum Annual Mean[b]	1.16
Maximum Annual Mean[b]	38.2
Average Annual Mean	7.6
Median Annual Mean	5.79
Population-Weighted Average Annual Mean[c]	14.2

[a] Based on public comment received on the proposed Large SI/Recreational Vehicle rule and other updated information, we revised our emissions estimates in some categories downwards and other categories upwards; however, on net, we believe this modeling would underestimate the baseline PM emissions without regulation.
[b] The minimum (maximum) is the value for the populated grid-cell with the lowest (highest) annual average.
[c] Calculated by summing the product of the projected 2030 grid-cell population and the estimated 2030 PM concentration, for that grid-cell and then dividing by the total population in the 48 contiguous States.

Nonroad engines and vehicles that are subject these standards contribute to ambient fine PM levels in two ways. First, they contribute through direct emissions of fine PM. As shown in Table 1.1-1, these engines emitted 14,600 tons of PM (about 2.1 percent of all mobile source PM) in 2000. As shown in Table 1.1-3, they are modeled to emit 36,500 tons of PM (about 4.8 percent of all mobile source PM) in 2030. Second, these engines contribute to indirect formation of PM through their emissions of gaseous precursors which are then transformed in the atmosphere into particles. For example, these engines emitted about 1,411,000 tons of HC or 23.5 percent of the HC emitted from mobile sources in 2030. Furthermore, recreational vehicles, such as snowmobiles and ATVs emit high levels of organic carbon (as HC) on a per engine basis. Some organic emissions are transformed into particles in the atmosphere and other volatile organics can condense if emitted in cold temperatures, as is the case for emissions from snowmobiles, for example. Organic carbon accounts for between 27 and 36 percent of ambient fine particle mass depending on the area of the country. The relationship between HC and PM have implications for the most efficient controls of ambient PM as discussed in Chapter 4.

Further, as discussed below, the nonroad engines we are regulating contribute to PM levels in areas with PM levels above 15 µg/m3.

1.5 Visibility Degradation

1.5.1 General Background

Visibility can be defined as the degree to which the atmosphere is transparent to visible light.[52] Visibility impairment has been considered the "best understood and most easily measured effect of air pollution."[53] Visibility degradation is often directly proportional to decreases in light transmittal in the atmosphere. Scattering and absorption by both gases and particles decrease light transmittance. It is an easily noticeable effect of fine PM present in the atmosphere, and fine PM is the major cause of reduced visibility in parts of the United States, including many of our national parks and in places where people live, work, and recreate. Fine particles with significant light-extinction efficiencies include organic matter, sulfates, nitrates, elemental carbon (soot), and soil.

Visibility is an important effect because it has direct significance to people's enjoyment of daily activities in all parts of the country. Individuals value good visibility for the well-being it provides them directly, both in where they live and work, and in places where they enjoy recreational opportunities. Visibility is highly valued in significant natural areas such as national parks and wilderness areas, because of the special emphasis given to protecting these lands now and for future generations.

To quantify changes in visibility, the analysis presented in this chapter computes a light-extinction coefficient, based on the work of Sisler, which shows the total fraction of light that is decreased per unit distance.[54] This coefficient accounts for the scattering and absorption of light by both particles and gases, and accounts for the higher extinction efficiency of fine particles compared to coarse particles. Visibility can be described in terms of visual range, light extinction or deciview.[6]

In addition to limiting the distance that one can see, the scattering and absorption of light caused by air pollution can also degrade the color, clarity, and contrast of scenes. Visibility impairment also has a temporal dimension in that impairment might relate to a short-term

[6]Visual range can be defined as the maximum distance at which one can identify a black object against the horizon sky. It is typically described in miles or kilometers. Light extinction is the sum of light scattering and absorption by particles and gases in the atmosphere. It is typically expressed in terms of inverse megameters (Mm^{-1}), with larger values representing worse visibility. The deciview metric describes perceived visual changes in a linear fashion over its entire range, analogous to the decibel scale for sound. A deciview of 0 represents pristine conditions. Under many scenic conditions, a change of 1 deciview is considered perceptible by the average person.

excursion or to longer periods (e.g., worst 20 percent of days or annual average levels). More detailed discussions of visibility effects are contained in the EPA Criteria Document for PM.

Visibility effects are manifest in two principal ways: (1) as local impairment (e.g., localized hazes and plumes) and (2) as regional haze. The emissions from engines covered by this rule contribute to both types of visibility impairment.

Local-scale visibility degradation is commonly in the form of either a plume resulting from the emissions of a specific source or small group of sources, or it is in the form of a localized haze such as an urban "brown cloud." Plumes are comprised of smoke, dust, or colored gas that obscure the sky or horizon relatively near sources. Impairment caused by a specific source or small group of sources has been generally termed as "reasonably attributable."

The second type of impairment, regional haze, results from pollutant emissions from a multitude of sources located across a broad geographic region. It impairs visibility in every direction over a large area, in some cases over multi-state regions. Regional haze masks objects on the horizon and reduces the contrast of nearby objects. The formation, extent, and intensity of regional haze is a function of meteorological and chemical processes, which sometimes cause fine particulate loadings to remain suspended in the atmosphere for several days and to be transported hundreds of kilometers from their sources.[55]

On an annual average basis, the concentrations of non-anthropogenic fine PM are generally small when compared with concentrations of fine particles from anthropogenic sources.[56] Anthropogenic contributions account for about one-third of the average extinction coefficient in the rural West and more than 80 percent in the rural East.[57] Because of significant differences related to visibility conditions in the eastern and western U.S., we present information about visibility by region. Furthermore, it is important to note that even in those areas with relatively low concentrations of anthropogenic fine particles, such as the Colorado plateau, small increases in anthropogenic fine particle concentrations can lead to significant decreases in visual range. This is one of the reasons Class I areas have been given special consideration under the Clean Air Act.

1.5.2 Visibility Impairment Where People Live, Work and Recreate

Visibility impairment occurs in many areas throughout the country, where people live, work, and recreate. In this section, in order to estimate the magnitude of the problem, we use monitored PM2.5 data and modeled air quality using emissions inventories from the engines subject to this rule. The engines covered by this rule contribute to PM2.5 levels in areas across the country with unacceptable visibility conditions.

1.5.2.1 Areas Affected by Visibility Impairment

The secondary PM NAAQS is designed to protect against adverse welfare effects such as visibility impairment. In 1997, the secondary PM NAAQS was set as equal to the primary (health-based) PM NAAQS (62 Federal Register No. 138, July 18, 1997). EPA concluded that PM can and does produce adverse effects on visibility in various locations, depending on PM concentrations and factors such as chemical composition and average relative humidity. In 1997, EPA demonstrated that visibility impairment is an important effect on public welfare and that visibility impairment is experienced throughout the U.S., in multi-state regions, urban areas, and remote Federal Class I areas.

In many cities having annual mean PM2.5 concentrations exceeding 17 ug/m3, improvements in annual average visibility resulting from the attainment of the annual PM2.5 standard are expected to be perceptible to the general population (e.g., to exceed 1 deciveiew). Based on annual mean monitored PM2.5 data, many cities in the Northeast, Midwest, and Southeast as well as Los Angeles would be expected to experience perceptible improvements in visibility if the PM2.5 annual standard were attained. For example, in Washington, DC, where the IMPROVE monitoring network shows annual mean PM2.5 concentrations at about 19 ug/m3 during the period of 1992 to1995, approximate annual average visibility would be expected to improve from 21 km (29 deciview) to 27 km (27 deciview). The PM2.5 annual average in Washington, DC, was 18.9 ug/m3 in 2000.

The updated monitored data and air quality modeling presented below confirm that the visibility situation identified during the NAAQS review in 1997 is still likely to exist. Specifically, there will still likely be a broad number of areas that are above the annual PM2.5 NAAQS in the Northeast, Midwest, Southeast and California , such that the determination in the NAAQS rulemaking about broad visibility impairment and related benefits from NAAQS compliance are still relevant. Thus, levels above the fine PM NAAQS cause adverse welfare impacts, such as visibility impairment (both regional and localized impairment).

In addition, in setting the PM NAAQS, EPA acknowledged that levels of fine particles below the NAAQS may also contribute to unacceptable visibility impairment and regional haze problems in some areas, and Clean Air Act Section 169 provides additional authorities to remedy existing impairment and prevent future impairment in the 156 national parks, forests and wilderness areas labeled as Class I areas.

In making determinations about the level of protection afforded by the secondary PM NAAQS, EPA considered how the Section 169 regional haze program and the secondary NAAQS would function together. Regional strategies are expected to improve visibility in many urban and non-Class I areas as well. The following recommendation for the National Research Council, Protecting Visibility in National Parks and Wilderness Areas (1993), addresses this point: “Efforts to improve visibility in Class I areas also would benefit visibility outside these areas. Because most visibility impairment is regional in scale, the same haze that degrades visibility within or looking out from a national park also degrade visibility outside it. Class I areas cannot be regarded as potential islands of clean air in a polluted sea.”

Visibility impairment (localized and regional haze) in Class I areas is discussed in the next section.

1.5.2.1.1 Areas Affected by Visibility Impairment: Monitored Data

The 1999-2000 $PM_{2.5}$ monitored values, which cover only a portion of the nation's counties, indicate that at least 82 million people live in areas where long-term ambient fine particulate matter levels are at or above 15 $\mu g/m^3$.[58] Thus, these populations (plus others who travel to these areas) would be experiencing visibility impairment that is unacceptable, and based on our modeling, emissions of PM and its precursors from engines in these categories contribute to this unacceptable impairment.

Another way to consider this information is to compare the values directly to the PM NAAQS in the format required by regulation. EPA regulations require 3 consecutive years of PM2.5 data in order to make comparisons with the National Ambient Air Quality Standards; see Part 50, Appendix N. In Table 1.5-1, we list areas with 1999 and 2000 monitored annual average PM2.5 levels above 15 ug/m3 in 2000, as represented by design values that can be compared to the PM2.5 NAAQS. There were a total of 129 counties representing 65 million people with levels above the design value for the annual PM2.5 NAAQS based on 1999 and 2000 monitored data. The table also notes areas which have made a note of "exceptional events" in their reporting of the monitored data.

Table 1.5-1.
Areas with Monitored Annual Average PM2.5 Concentrations Above 15 ug/m3.

EPA regulations require 3 consecutive years of PM2.5 data in order to make comparisons with the National Ambient Air Quality Standards; see Part 50, Appendix N. The data represented in this table reflect air quality monitoring from 1999 to 2001, although not all data have been verified by the monitoring agency.

State	County	Population 2000	Annual PM2.5 Standard Design Value	Design Value Data Flagged for Exceptional Events? 1
ALABAMA	CLAY	14,254	15.5	
ALABAMA	COLBERT	54,984	15.3	
ALABAMA	DE KALB	64,452	16.8	
ALABAMA	HOUSTON	88,787	16.3	
ALABAMA	JEFFERSON*	662,047	20.8*	
* Two sites in Jefferson County are encompassed in a Community Monitoring Zone (i.e. utilize spatial averaging); the spatially averaged design value for the CMZ is 20.8, which is the maximum for the county.				
ALABAMA	MADISON	276,700	15.5	
ALABAMA	MOBILE	399,843	15.3	
ALABAMA	MONTGOMERY	223,510	16.8	
ALABAMA	MORGAN	111,064	19.1	
ALABAMA	RUSSELL	49,756	18.4	
ALABAMA	SHELBY	143,293	17.2	
ALABAMA	TALLADEGA	80,321	17.8	
CALIFORNIA	BUTTE	203,171	15.4	yes
CALIFORNIA	FRESNO	799,407	24.0	yes
CALIFORNIA	IMPERIAL	142,361	15.7	
CALIFORNIA	KERN	661,645	23.7	yes
CALIFORNIA	KINGS	129,461	16.6	
CALIFORNIA	LOS ANGELES	9,519,338	25.9	
CALIFORNIA	MERCED	210,554	18.9	yes
CALIFORNIA	ORANGE	2,846,289	22.4	
CALIFORNIA 2	RIVERSIDE	1,545,387	29.8	
CALIFORNIA 2	SAN BERNARDINO	1,709,434	25.8	
CALIFORNIA	SAN DIEGO	2,813,833	17.1	
CALIFORNIA	SAN JOAQUIN	563,598	16.4	yes
CALIFORNIA	STANISLAUS	446,997	19.7	yes

State	County	Population 2000	Annual Std Design Value	DataFlagged for Exc. Events?1
CALIFORNIA	TULARE	368,021	24.7	
CONNECTICUT	NEW HAVEN	824,008	16.8	
DELAWARE	NEW CASTLE	500,265	16.6	
DISTRICT OF COLUMBIA	WASHINGTON	572,059	16.6	yes
GEORGIA	BIBB	153,887	17.6	
GEORGIA	CHATHAM	232,048	16.5	
GEORGIA	CLARKE	101,489	18.6	
GEORGIA	CLAYTON	236,517	19.2	
GEORGIA	COBB	607,751	18.6	
GEORGIA	DE KALB	665,865	19.6	
GEORGIA	DOUGHERTY	96,065	16.6	
GEORGIA	FLOYD	90,565	18.5	yes
GEORGIA	FULTON	816,006	21.2	
GEORGIA	HALL	139,277	17.2	
GEORGIA	MUSCOGEE	186,291	18.0	
GEORGIA	PAULDING	81,678	16.8	
GEORGIA	RICHMOND	199,775	17.4	
GEORGIA	WASHINGTON	21,176	16.5	
GEORGIA	WILKINSON	10,220	18.1	
ILLINOIS	COOK	5,376,741	18.8	
ILLINOIS	DU PAGE	904,161	15.4	
ILLINOIS	MADISON	258,941	17.3	
ILLINOIS	ST CLAIR	256,082	17.4	
ILLINOIS	WILL	502,266	15.9	
INDIANA	CLARK	96,472	17.3	
INDIANA	FLOYD	70,823	15.6	
INDIANA	LAKE	484,564	16.3	
INDIANA	MARION	860,454	17.0	
KENTUCKY	BOYD	49,752	15.5	yes
KENTUCKY	BULLITT	61,236	16.0	yes
KENTUCKY	CAMPBELL	88,616	15.5	yes
KENTUCKY	FAYETTE	260,512	16.8	yes
KENTUCKY	JEFFERSON	693,604	17.1	
KENTUCKY	KENTON	151,464	15.9	yes

State	County	Population 2000	Annual Std Design Value	DataFlagged for Exc. Events?1
KENTUCKY	MC CRACKEN	65,514	15.1	yes
KENTUCKY	PIKE	68,736	16.1	yes
KENTUCKY	WARREN	92,522	15.4	yes
MARYLAND	BALTIMORE (CITY)	651,154	17.8	
MICHIGAN	WAYNE	2,061,162	18.9	
MISSISSIPPI	HINDS	250,800	15.1	
MISSISSIPPI	JONES	64,958	16.6	
MISSOURI	ST LOUIS (CITY)	348,189	16.3	
MONTANA	LINCOLN	18,837	16.4	
NEW JERSEY	HUDSON	608,975	17.5	
NEW JERSEY	UNION	522,541	16.3	
NEW YORK	NEW YORK	1,537,195	17.8	yes
NORTH CAROLINA	ALAMANCE	130,800	15.3	
NORTH CAROLINA	CABARRUS	131,063	15.7	yes
NORTH CAROLINA	CATAWBA	141,685	17.1	yes
NORTH CAROLINA	CUMBERLAND	302,963	15.4	yes
NORTH CAROLINA	DAVIDSON	147,246	17.3	yes
NORTH CAROLINA	DURHAM	223,314	15.3	
NORTH CAROLINA	FORSYTH	306,067	16.2	yes
NORTH CAROLINA	GASTON	190,365	15.3	yes
NORTH CAROLINA	GUILFORD	421,048	16.3	yes
NORTH CAROLINA	HAYWOOD	54,033	15.4	yes
NORTH CAROLINA	MC DOWELL	42,151	16.2	yes
NORTH CAROLINA	MECKLENBURG	695,454	16.8	yes
NORTH CAROLINA	MITCHELL	15,687	15.5	yes
NORTH CAROLINA	WAKE	627,846	15.3	yes
OHIO	BUTLER	332,807	17.4	
OHIO	CUYAHOGA	1,393,978	20.3	

State	County	Population 2000	Annual Std Design Value	DataFlagged for Exc. Events?1
OHIO	FRANKLIN	1,068,978	18.1	
OHIO	HAMILTON	845,303	19.3	
OHIO	JEFFERSON	73,894	18.9	
OHIO	LORAIN	284,664	15.1	
OHIO	MAHONING	257,555	16.4	
OHIO	MONTGOMERY	559,062	17.6	
OHIO	PORTAGE	152,061	15.3	
OHIO	SCIOTO	79,195	20.0	
OHIO	STARK	378,098	18.3	
OHIO	SUMMIT	542,899	17.3	
OHIO	TRUMBULL	225,116	16.2	
PENNSYLVANIA	ALLEGHENY	1,281,666	21.0	
PENNSYLVANIA	BERKS	373,638	15.6	
PENNSYLVANIA	CAMBRIA	152,598	15.3	
PENNSYLVANIA	DAUPHIN	251,798	15.5	
PENNSYLVANIA	LANCASTER	470,658	16.9	
PENNSYLVANIA	PHILADELPHIA	1,517,550	16.6	
PENNSYLVANIA	WASHINGTON	202,897	15.5	
PENNSYLVANIA	WESTMORELAND	369,993	15.6	
PENNSYLVANIA	YORK	381,751	16.3	
SOUTH CAROLINA	GREENVILLE	379,616	17.0	yes
SOUTH CAROLINA	LEXINGTON	216,014	15.6	yes
SOUTH CAROLINA	RICHLAND	320,677	15.4	yes
SOUTH CAROLINA	SPARTANBURG	253,791	15.4	yes
TENNESSEE	DAVIDSON	569,891	17.0	
TENNESSEE	HAMILTON	307,896	18.9	
TENNESSEE	KNOX	382,032	20.4	yes
TENNESSEE	ROANE	51,910	17.0	yes
TENNESSEE	SHELBY	897,472	15.6	
TENNESSEE	SULLIVAN	153,048	17.0	yes
				DataFlagged

State	County	Population 2000	Annual Std Design Value	for Exc. Events?1
TENNESSEE	SUMNER	130,449	15.7	
VIRGINIA	BRISTOL	17,367	16.0	yes
VIRGINIA	ROANOKE (CITY)	94,911	15.2	yes
WEST VIRGINIA	BERKELEY	75,905	16.0	
WEST VIRGINIA	BROOKE	25,447	17.4	
WEST VIRGINIA	CABELL	96,784	17.8	yes
WEST VIRGINIA	HANCOCK	32,667	17.4	
WEST VIRGINIA	KANAWHA	200,073	18.4	yes
WEST VIRGINIA	MARSHALL	35,519	16.5	
WEST VIRGINIA	OHIO	47,427	15.7	
WEST VIRGINIA	WOOD	87,986	17.6	yes
TOTAL	**129 Counties**	**65,185,812**		

1. Design Values include all valid data. Some valid data were impacted by exceptional events. These special situations are being reviewed by EPA.

2. Sacramento County CA does not exceed the PM2.5 annual standard but does exceed the daily standard.

Source: EPA Trends Reports

1.5.2.1.2 Areas Affected by Visibility Impairment: Modeled Future PM Levels and Visibility Index Estimates

Because the chemical composition of the PM affects visibility impairment, we used REMSAD air quality model to project visibility conditions in 2030 accounting for the chemical composition of the particles and to estimate visibility impairment directly as changes in deciview. Our projections included anticipated emissions from the engines subject to this rule, and although our emission predictions reflected our best estimates of emissions projections at the time the modeling was conducted, we now have new estimates, as discussed above in Table 1.1-4. Based on public comment for this rule and new information, we have revised our emissions estimates in some categories downwards and other categories upwards; however, on net, we believe the HD07 modeling underestimates the PM air quality levels that would be predicted if new inventories were used.

The most reliable information about the future visibility levels would be in areas for which monitoring data are available to evaluate model performance for a base year (e.g., 1996). Accordingly, we predicted that in 2030, 49 percent of the population will be living in areas where fine PM levels are above 15 µg/m3 and monitors are available.[59] This can be compared with the 1996 level of 37 percent of the population living in areas where fine PM levels are above 15 µg/m3 and monitors are available.

Based upon the light-extinction coefficient, we also calculated a unitless visibility index, called a "deciview," which is used in the valuation of visibility. The deciview metric provides a linear scale for perceived visual changes over the entire range of conditions, from clear to hazy. Under many scenic conditions, the average person can generally perceive a change of one deciview. The higher the deciview value, the worse the visibility. Thus, an improvement in visibility is a decrease in deciview value.

As shown in Table 1.5-2, in 2030 we estimate visibility in the East to be about 19 deciviews (or visual range of 60 kilometers) on average, with poorer visibility in urban areas, compared to the visibility conditions without man-made pollution of 9.5 deciviews (or visual range of 150 kilometers). Likewise, in we estimate visibility in the West to be about 9.5 deciviews (or visual range of 150 kilometers) in 2030, compared to the visibility conditions without man-made pollution of 5.3 deciviews (or visual range of 230 kilometers). Thus, in the future, a substantial percent of the population may experience unacceptable visibility impairment in areas where they live, work and recreate.

Table 1.5-2
Summary of 2030 National Visibility Conditions Based on REMSAD Modeling (Deciviews)

Regions[b]	Predicted 2030 Visibility[a] (annual average)	Natural Background Visibility
Eastern U.S.	18.98	9.5
Urban	20.48	
Rural	18.38	
Western U.S.	9.54	5.3
Urban	10.21	
Rural	9.39	

[a] The results incorporate earlier emissions estimates from the engines subject to this rule. We have revised our estimates both upwards for some categories and downwards for others based on public comment and updated information; however, on net, we believe that the results would underestimate future PM emissions.
[b] Eastern and Western Regions are separated by 100 degrees north longitude. Background visibility conditions differ by region.

The emissions from nonroad engines generally, and in particular the engines subject to this rule, contribute to this visibility impairment shown in Table 1.5-2. Nonroad engines emissions contribute a large portion of the total PM emissions from mobile sources and anthropogenic sources, in general. These emissions occur in and around areas with PM levels above the annual PM2.5 NAAQS. The engines subject to the final rule will contribute to these effects. They are estimated to emit 36,500 tons of direct PM in 2030, which is 1.1 percent of the total anthropogenic PM emissions in 2030. Similarly, for PM precursors, the engines subject to this rule will emit 640,000 tons of NOx and 1,411,000 tons HC in 2030, which are 3.8 and 8.3 percent of the total anthropogenic NOx and HC emissions, respectively, in 2030. Recreational vehicles in particular contribute to these levels. In Table I.E-1 through I.E-3, we show that recreational vehicles emitted about 1.7 percent of mobile source PM emissions in 2000. Similarly, recreational vehicles are modeled to emit over 4 percent of mobile source PM in 2020 and 2030. Thus, the emissions from these sources contribute to the visibility impairment modeled for 2030 summarized in the table.

Snowmobiles are operated in and around areas with PM2.5 levels above the level of the secondary NAAQS. For 20 counties across nine states, snowmobile trails are found within or near counties that registered ambient $PM_{2.5}$ concentrations at or above 15 μg/m^3, the level of the $PM_{2.5}$ NAAQS.[7] These counties are listed in Table 1.5-3. To obtain the information about

[7] Memo to file from Terence Fitz-Simons, OAQPS, Scott Mathias, OAQPS, Mike Rizzo, Region 5, "Analyses of 1999 PM Data for the PM NAAQS Review," November 17, 2000, with attachment B, 1999 PM2.5 Annual Mean and 98th Percentile 24-Hour Average Concentrations.

snowmobile trails contained in the table, we consulted snowmobile trail maps that were supplied by various states.[60] Fine particles may remain suspended for days or weeks and travel hundreds to thousands of kilometers, and thus fine particles emitted or created in one county may contribute to ambient concentrations in a neighboring county.[8]

Docket No. A-2000-01, Document No. II-B-17.

[8]Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment for Scientific and Technical Information, OAQPS Staff Paper, EPA-452\R-96-013, July, 1996, at IV-7. This document is available from Docket A-99-06, Document II-A-23.

Table 1.5-3
Counties with Annual $PM_{2.5}$ Levels Above 16 µg/m3 and Snowmobile Trails

State	$PM_{2.5}$ Exceedances County	County with Snowmobile Trails	Proximity to $PM_{2.5}$ Exceedances County
Ohio	Machining	Machining	Same County
	Trumbull	Trumbull	Same County
	Summit	Summit	Same County
	Montgomery	Montgomery	Same County
	Portage	Portage	Same County
	Franklin	Delaware	Borders North
	Marshall/Ohio (WV)	Belmont	Borders West
Montana	Lincoln	Lincoln	Same County
California	Tulane	Tulane	Same County
	Butte	Butte	Same County
	Fresno	Fresno	Same County
	Kern	Kern	Same County
Minnesota	Washington	Washington	Same County
	Wright	Wright	Same County
Wisconsin	Waukesha	Waukesha	Same County
	Milwaukee	Milwaukee	Same County
Oregon	Jackson	Douglas	Borders NNE
	Klammath	Douglas	Borders North
Pennsylvania	Washington	Layette	Borders East
		Somerset	—
Illinois	Rock Island	Rock Island	Same County
		Henry	Borders East
Iowa	Rock Island (IL)	Dubuque	Borders West

Achieving the annual $PM_{2.5}$ NAAQS will help improve visibility across the country, but it will not be sufficient (64 FR 35722 July 1, 1999 and 62 FR July 18, 1997 PM NAAQS). In setting the NAAQS, EPA discussed how the NAAQS in combination with the regional haze program, is deemed to improve visibility consistent with the goals of the CAA. In the East, there are wide areas above 15 ug/m^3 and light extinction is significantly above natural background. Thus, large areas of the Eastern United States have air pollution that is causing unacceptable visibility problems. In the West, scenic vistas are especially important to public welfare. Although the annual $PM_{2.5}$ NAAQS is met in most areas outside of California, virtually the entire West is in close proximity to a scenic Class I area protected by 169A and 169B of the CAA.

1.5.3 Visibility Impairment in Class I Areas

The Clean Air Act establishes special goals for improving visibility in many national parks, wilderness areas, and international parks. In the 1977 amendments to the Clean Air Act, Congress set as a national goal for visibility the "prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I Federal areas which impairment results from manmade air pollution" (CAA section 169A(a)(1)). The Amendments called for EPA to issue regulations requiring States to develop implementation plans that assure "reasonable progress" toward meeting the national goal (CAA Section 169A(a)(4)). EPA issued regulations in 1980 to address visibility problems that are "reasonably attributable" to a single source or small group of sources, but deferred action on regulations related to regional haze, a type of visibility impairment that is caused by the emission of air pollutants by numerous emission sources located across a broad geographic region. At that time, EPA acknowledged that the regulations were only the first phase for addressing visibility impairment. Regulations dealing with regional haze were deferred until improved techniques were developed for monitoring, for air quality modeling, and for understanding the specific pollutants contributing to regional haze.

In the 1990 Clean Air Act amendments, Congress provided additional emphasis on regional haze issues (see CAA section 169B). In 1999 EPA finalized a rule that calls for States to establish goals and emission reduction strategies for improving visibility in all 156 mandatory Class I national parks and wilderness areas. In this rule, EPA established a "natural visibility" goal.[61] In that rule, EPA also encouraged the States to work together in developing and implementing their air quality plans. The regional haze program is focused on long-term emissions decreases from the entire regional emissions inventory comprised of major and minor stationary sources, area sources and mobile sources. The regional haze program is designed to improve visibility and air quality in our most treasured natural areas from these broad sources. At the same time, control strategies designed to improve visibility in the national parks and wilderness areas will improve visibility over broad geographic areas. In the PM NAAQS rulemaking, EPA also anticipated the need in addition to the NAAQS and Section 169 regional haze program to continue to address localized impairment that may relate to unique circumstances in some Western areas. For mobile sources, there may also be a need for a Federal role in reduction of those emissions, in particular, because mobile sources are regulated primarily at the federal level.

As described above, regional haze is caused by the emission from numerous sources located over a wide geographic area.[62] Visibility impairment is caused by pollutants (mostly fine particles and precursor gases) directly emitted to the atmosphere by several activities (such as electric power generation, various industry and manufacturing processes, truck and auto emissions, construction activities, etc.). These gases and particles scatter and absorb light, removing it from the sight path and creating a hazy condition. Visibility impairment is caused by both regional haze and localized impairment.

Because of evidence that fine particles are frequently transported hundreds of miles, all 50 states, including those that do not have Class I areas, participate in planning, analysis and, in many cases, emission control programs under the regional haze regulations. Even though a given State may not have any Class I areas, pollution that occurs in that State may contribute to impairment in Class I areas elsewhere. The rule encourages states to work together to determine whether or how much emissions from sources in a given state affect visibility in a downwind Class I area.

The regional haze program calls for states to establish goals for improving visibility in national parks and wilderness areas to improve visibility on the haziest 20 percent of days and to ensure that no degradation occurs on the clearest 20 percent of days. The rule requires states to develop long-term strategies including enforceable measures designed to meet reasonable progress goals toward natural visibility conditions. Under the regional haze program, States can take credit for improvements in air quality achieved as a result of other Clean Air Act programs, including national mobile-source programs.[9]

As noted above, EPA issued regulations in 1980 to address Class I area localized visibility impairment that is "reasonably attributable" to a single source or small group of sources. In 40 CFR Part 51.301 of the visibility regulations, visibility impairment is defined as "any humanly perceptible change in visibility (light extinction, visual range, contrast, coloration) from that which would have existed under natural conditions." States are required to develop implementation plans that include long-term strategies for improving visibility in each Class I area. The long-term strategies under the 1980 regulations should consist of measures to reduce impacts from local sources and groups of sources that contribute to poor air quality days in the

[9] Though a recent case, American Corn Growers Association v. EPA, 291F.3d 1(D.C .Cir 2002) vacated the BART provisions of the Regional Haze rule, the court denied industry's challenge to EPA's requirement that state's SIPS provide for reasonable progress towards achieving natural visibility conditions in national parks and wilderness areas and the "no degradation" requirement. Industry did not challenge requirements to improve visibility on the haziest 20 percent of days. The court recognized that mobile source emission reductions would need to be a part of a long-term emission strategy for reducing regional haze. A copy of this decision can be found in Docket A-2000-01, Document IV- A-113.

class I area. Types of impairment covered by these regulations includes layered hazes and visible plumes. While these kinds of visibility impairment can be caused by the same pollutants and processes as those that cause regional haze, they generally are attributed to a smaller number of sources located across a smaller area. The Clean Air Act and associated regulations call for protection of visibility impairment in Class I areas from localized impacts as well as broader impacts associated with regional haze.

As part of the HD07 PM air quality modeling described above, we modeled visibility conditions in the Class I areas nationally. The results by region are summarized in Table 1.5-4. In Figure 1.5-1, we define the regions used in this analysis based on a visibility study.[63] These results show that visibility is impaired in most Class I areas and additional reductions from behicles subject to this rule are needed to achieve the goals of the Clean Air Act of preserving natural conditions in Class I areas.

Table 1.5-4
Summary of 2030 Visibility Conditions in Class I Areas Based on REMSAD Modeling (Annual Average Deciview)

Region	Predicted 2030 Visibility	Natural Background Visibility
Eastern		9.5
Southeast	25.02	
Northeast/Midwest	21.00	
Western		5.3
Southwest	8.69	
California	11.61	
Rocky Mountain	12.30	
Northwest	15.44	
National Class I Area Average	14.04	

[a] Regions are depicted in Figure 1-5.1. Background visibility conditions differ by region based on differences in relative humidity and other factors: Eastern natural background is 9.5 deciviews (or visual range of 150 kilometers) and in the West natural background is 5.3 deciviews (or visual range of 230 kilometers).

[b] The results incorporate earlier emissions estimates from the engines subject to this rule. We have revised our estimates both upwards for some categories and downwards for others based on public comment and updated information; however, on net, we believe that the HD07 analyses underestimate future PM emissions.

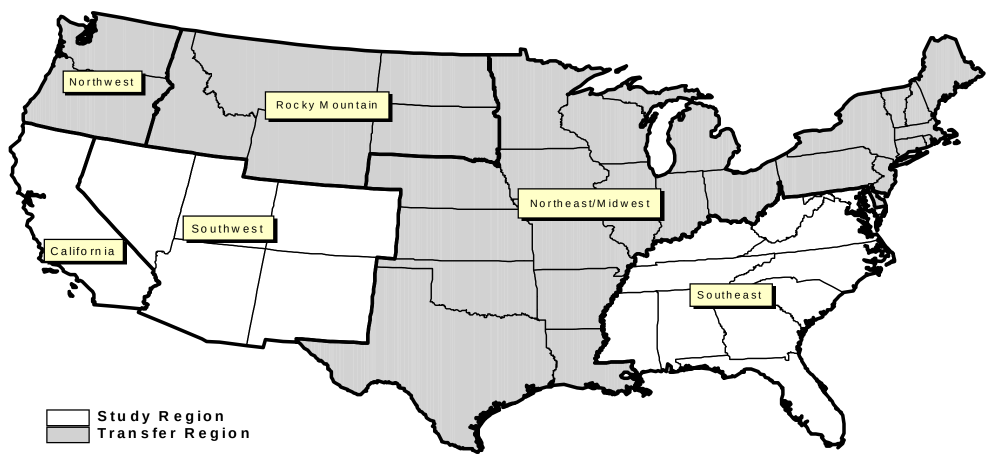


Figure 1.5-1. Visibility Regions for Continental U.S.

Note: Study regions were represented in the Chestnut and Rowe (1990a, 1990b) studies used in evaluating the benefits of visibility improvements.

The overall goal of the regional haze program is to prevent future and remedy existing visibility impairment in Class I areas. As shown by the future deciview estimates in Table 1.5-4, additional emissions reductions will be needed from the broad set of sources that contribute, including the emissions from engines subject to this rule.

1.5.4 Recreational Vehicles and Visibility Impairment in Class I Areas

This section presents information about the contribution of recreational vehicles to visibility impairment in Class I areas. Although this discussion focuses primarily on snowmobiles, we present information on other recreational vehicles as well. We use monitoring data to show that many of the worst 20 percent of days in terms of visibility levels occur in the wintertime, when snowmobiles are used. We also summarize air quality modeling information of future visibility for Class I areas where snowmobiles are operated and a case study of localized impairment in a national park.

1.5.4.1 Snowmobiles Emissions in Class I Areas

Emissions of HC from snowmobiles contribute to direct and secondary formation of fine particulate matter which can cause a variety of adverse health and welfare effects, including visibility impairment discussed above. This section presents snowmobile-related emissions information for Class I areas where snowmobiles are operated as further evidence of their contribution in Class I areas.

Ambient concentrations of fine particles are the primary pollutant responsible for visibility impairment. The classes of fine particles principally responsible for visibility impairment are sulfates, nitrates, organic carbon particles, elemental carbon, and crustal material. Hydrocarbon emissions from automobiles, trucks, snowmobiles, and other industrial processes are common sources of organic carbon. The organic carbon fraction of fine particles ranges from 47 percent in western Class I areas such as Denali National Park, to 28 percent in Rocky Mountain National Park, to 13 percent in Acadia National Park.[64]

The contribution of snowmobiles to elemental carbon and nitrates is relatively small. Their contribution to sulfates is a function of fuel sulfur and is small and will decrease even more as the sulfur content of their fuel decreases due to our recently finalized fuel sulfur requirements. In the winter months, however, hydrocarbon emissions from snowmobiles can be significant, as indicated in Table 1.5-5 and these HC emissions can contribute significantly to the organic carbon fraction of fine particles which are largely responsible for visibility impairment. This is because snowmobiles are typically powered by two-stroke engines that emit large amounts of hydrocarbons. In Yellowstone, a park with high snowmobile usage during the winter months, snowmobile hydrocarbon emissions can exceed 500 tons per year, as much as several large stationary sources. Other parks with less snowmobile traffic are also impacted, though to a lesser extent, by these hydrocarbon emissions.[65]

Table 1.5-5
1999 Winter Season Snowmobile Emissions in Selected Class I Areas (tons)

Class I area	HC	CO	NOx	PM
Denali NP and Preserve	>9.8	>26.1	>0.08	>0.24
Grand Teton NP	13.7	36.6	0.1	0.3
Rocky Mountain NP	106.7	284.7	0.8	2.6
Voyager NP	138.5	369.4	1.1	3.4
Yellowstone NP	492	1311.9	3.8	12

Source: Letter from Aaron J. Worstell, Environmental Engineer, National Park Service, Air Resources Division, to Drew Kodjak, August 21, 2001, particularly Table 1. Docket No. A-2000-01, Document No. II-G-178.

The national park areas outside of Denali in Alaska are open to snowmobile operation in accordance with special regulations (36 CFR Part 7). Denali National Park permits snowmobile operation by local rural residents engaged in subsistence uses (36 CFR Part 13). Emission calculations are based on an assumed 2 hours of use per snowmobile visit at 16 hp with the exception of Yellowstone where 4 hours of use at 16 hp was assumed. The emission factors used to estimate these emissions are identical to those used by the NONROAD model. Two-stroke snowmobile emission factors are: 111 g/hp-hr HC, 296 g/hp-hr CO, 0.86 g/hp-hr NOx, and 2.7

g/hp-hr PM. These emission factors are based on a number of engine tests performed by the International Snowmobile Manufacturers Association (ISMA) and the Southwest Research Institute (SwRI).

1.5.4.2 Air Quality Monitoring Information

To explore whether recreational vehicles, such as snowmobiles, contribute to visibility impairment in Class I areas, we examine current monitored PM levels. Visibility and particulate monitoring data are available for 8 Class I areas where snowmobiles are commonly used. These are Acadia, Boundary Waters, Denali, Mount Ranier, Rocky Mountain, Sequoia and Kings Ganyon, Voyager, and Yellowstone. Monitored fine particle data for these parks are set out in Table 1.5-6. This table shows the number of monitored days in the winter that fell within the 20-percent haziest days for each of these eight parks. Monitors collect data two days a week for a total of about 104 days of monitored values. Thus, for a particular site, a maximum of 21 worst possible days of these 104 days with monitored values constitute the set of 20-percent haziest days during a year which are tracked as the primary focus of regulatory efforts.[66] With the exception of Denali in Alaska, we defined the snowmobile season as January 1 through March 15 and December 15 through December 31 of the same calendar year, consistent with the methodology used in the Regional Haze Rule, which is calendar-year based. For Denali, Alaska, the snowmobile season is October 1 to April 30.

Table 1.5-6
Winter Days That Fall Within the 20 Percent Worst Visibility Days At National Parks Where Snowmobiles Are Operated

Class I Area	State(s)	Number of Sampled Wintertime Days Within 20 Percent Worst Visibility Days (maximum of 21 out of 104 monitored days)			
		1996	1997	1998	1999
Acadia NP	ME	4	4	2	1
Denali NP and Preserve	AK	10	10	12	9
Mount Rainier NP	WA	1	3	1	1
Rocky Mountain NP	CO	2	1	2	1
Sequoia and Kings Canyon NP	CA	4	9	1	8
Voyager NP (1989-1992)	MN	1989 3	1990 4	1991 6	1992 8
-- Boundary Waters USFS Wilderness Area (close to Voyaguers with recent data)	MN	2	5	1	5
Yellowstone NP	ID, MT, WY	0	2	0	0

Source: Letter from Debra C. Miller, Data Analyst, National Park Service, to Drew Kodjak, August 22, 2001. Docket No. A-2000-01.

1.5.4.3 Future Visibility Impairment in Class I Areas: Regional Haze

We also examined future air quality information to whether the emissions from recreational vehicles, such as snowmobiles, contribute to regional visibility impairment in Class I areas. We present results from the HD07 future air quality modeling described above for these Class I areas in addition to inventory and air quality measurements. Specifically, in Table 1-5.7, we summarize the expected future visibility conditions in these areas without these regulations.

Table 1.5-7
Estimated 2030 Visibility in Selected Class I Areas

Class I Area	County	State	Predicted 2030 Visibility (annual average deciview)	Natural Background Visibility (annual average deciview)
Eastern areas				
Acadia	Hancock Co	ME	23.42	9.5
Boundary Waters	St. Louis Co	MN	22.07	
Voyager	St. Louis Co	MN	22.07	
Western areas				
Grand Teton NP	Teton Co	WY	11.97	
Kings Canyon	Fresno Co	CA	10.39	5.3
Mount Rainier	Lewis Co	WA	16.19	
Rocky Mountain	Larimer Co	CO	8.11	
Sequoia-Kings	Tulare Co	CA	9.36	
Yellowstone	Teton Co	WY	11.97	

[a] Natural background visibility conditions differ by region because of differences in factors such as relative humidity: Eastern natural background is 9.5 deciviews (or visual range of 150 kilometers) and in the West natural background is 5.3 deciviews (or visual range of 230 kilometers).
[b] The results incorporate earlier emissions estimates from the engines subject to this rule. We have revised our estimates both upwards for some categories and downwards for others based on public comment and updated information; however, on net, we believe that HD07 analysis would underestimate future PM emissions from these categories.

In these areas, snowmobiles represent a signficant part of wintertime visibility-impairing emissions. In fact, as the following discussion shows, snowmobile emissions can even be a sizable percentage of annual emissions in some Class I areas. The snowmobiles thus are a significant contributor to visibility impairment in these areas during the winter. As indicated, winter days can often be among the worst visibility impairment. In addition, as the CAA specifically states a goal of prevention and of remedying of <u>any</u> impairment of visibility in Class I areas, the contribution of snowmobiles to visibility impairment even on winter days that are not among the days of greatest impairment is a contribution to pollution that may reasonably be anticipated to endanger public welfare and is properly regulated in this rule.

The information presented in Table 1.5-6 shows that visibility data supports a conclusion that there are at least 8 Class I areas frequented by snowmobiles with one or more wintertime days within the 20-percent worst visibility days of the year. For example, Rocky Mountain National Park in Colorado was frequented by about 27,000 snowmobiles during the 1998-1999 winter. Of the monitored days characterized as within the 20-percent worst visibility monitored days, 2 of those days occurred during the wintertime when snowmobile emissions such as HC contributed to visibility impairment. The information in Table 1.5-7 shows that these areas also have high predicted annual average deciview levels in the future. According to the National Park Service, "[s]ignificant differences in haziness occur at all eight sites between the averages of the clearest and haziest days. Differences in mean standard visual range on the clearest and haziest days fall in the approximate range of 115-170 km."[67]

1.5.4.4 Localized Visibility Impairment in Class I Areas: Yellowstone National Park

The Class I are with the most detailed analysis of snowmobile contribution is Yellowstone National Park. This provides an example of the extent to which snowmobiles can contribute to emissions that can cause visibility impairment in Class I areas. Annual and particularly wintertime hydrocarbon emissions from snowmobiles are high in the five parks considered in Table 1.5-7, with two parks having HC emissions nearly as high as Yellowstone (Rocky Mountain and Voyageurs). The proportion of snowmobile emissions to emissions from other sources affecting air quality in these parks is likely to be similar to that in Yellowstone.

Inventory analysis performed by the National Park Service for Yellowstone National Park suggests that snowmobile emissions can be a significant source of total annual mobile source emissions for the park year round. Table 1.5-8 shows that in the 1998 winter season snowmobiles contributed 64 percent, 39 percent, and 30 percent of HC, CO, and PM emissions.[68] When the emission factors used by EPA in its NONROAD model are used, the contribution of snowmobiles to total emissions in Yellowstone is still high: 59 percent, 33 percent, and 45 percent of HC, CO and PM emissions. The University of Denver used remote-sensing equipment to estimate snowmobile HC emissions at Yellowstone during the winter of 1998-1999, and estimated that snowmobiles contribute 77 percent of annual HC emissions at the park.[69] The portion of wintertime emissions attributable to snowmobiles is even higher, since all snowmobile emissions occur during the winter months.

Table 1.5-8
1998 Annual HC Emissions (tons per year), Yellowstone National Park

Source	HC		CO		NOx		PM	
Coaches	2.69	0%	24.29	1%	0.42	0%	0.01	0%
Autos	307.17	33%	2,242.12	54%	285.51	88%	12.20	60%
RVs	15.37	2%	269.61	6%	24.33	7%	0.90	4%
Snowmobiles	596.22	64%	1,636.44	39%	1.79	1%	6.07	30%
Buses	4.96	1%	18.00	0%	13.03	4%	1.07	5%
TOTAL	926.4		4190.46		325.08		20.25	

Source: National Park Service, February 2000. Air Quality Concerns Related to Snowmobile Usage in National Parks. Air Docket A-2000-01, Document No. II-A-44.

As part of public comments, Sierra Research conducted modeling of local impairment using EPA's SCREEN3 Model Version 96043. This methodology consists of a single source Gaussian plume model, which provides maximum ground-level concentrations for point, area, flare, and volume sources, as well as concentrations in the cavity zone and concentrations due to inversion break-up and shoreline fumigation.

The Sierra Research modeling demonstrated that there is up to an 8 percent contribution to visibility degradation from snowmobile exhaust based on worst case conditions in Yellowstone national park. It should be noted that SCREEN3 is not an EPA-approved model for conducting visibility modeling. In interpreting the results of this modeling, the International Snowmobile Manufacturers Association (ISMA) notes that the conversion factors used by SCREEN3 are "conservatively high" and meant for worst case conditions, where there is a "pronounced [wind] polarity…such as where a sea breeze exists."[70] Consequently, ISMA appears to believe that data gathered away from a coastline would actually have a lower demonstrated visual impact than the impact determined by the model. Even using this modeling, ISMA presents modeling results that support an 8 percent contribution to visibility impairment. ISMA reasons that by using the same model for automobiles, the impairment contribution is double of what was expected, and therefore, the 8 percent is most likely double of what it should be. As a result, ISMA concludes an up to 4% contribution to visibility impairment from snowmobile emissions in national parks "on best visibility days."[71] Though the contribution levels in this industry-sponsored study are lower than those discussed above, and though we have some concerns with this study, as discussed in the Summary and Analysis of Comments, they still confirm that snowmobiles are indeed a significant contributor to visibility degradation in Yellowstone.

In addition to the national modeling presented in Tables 1.4-3, 1.5-1, and 1.5-6, we also conducted local-scale modeling using an EPA-approved visibility model, VISCREEN Version 1.01, to evaluate whether current emissions from recreational vehicles, such as snowmobiles, contribute to localized visibility impairment in Class I areas. This analysis focused on localized visibility impairments in Yellowstone National Park.[72] The VISCREEN model is a visibility screening level-I and -II model that characterizes point source plumes and visibility effects at 34 lines of sight. Thus, in this modeling, EPA treated snowmobiles as a synthetic point source in order to determine plume perceptibility effects in a national park.

Using VISCREEN Version 1.01, we determined plume perceptibility from snowmobile usage at four entrances (North, South, East, and West) in Yellowstone National Park as a case study of visibility impairment from recreational vehicles. We conclude that plume perceptibility would be noticeable at all entrances, even at the North entrance where the smallest numbers of snowmobiles enter. Variations in the parameters concluded that perceptibility increased as the observer neared the plume and at smaller plume-offset angles. As well, a sensitivity analysis was conducted in order to demonstrate visibility impairment when the source is located within the Class I boundaries and concluded that visibility impairment increases if the source is located within the boundary. This provides further proof that snowmobile usage can lead to visibility impairment at Yellowstone.

These results all indicate that snowmobiles contribute to visibility impairment concerns in Yellowstone National Park, a Class I area.

1.6 Gaseous Air Toxics

In addition to the human health and welfare impacts described above, emissions from the engines covered by this rulemaking also contain several other substances that are known or suspected human or animal carcinogens, or have serious non-cancer health effects. These include benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, and toluene. The health effects of these air toxics are highlighted below. Additional information can also be found in the Technical Support Document four our final Mobile Source Air Toxics rule.[73]

1.6.1 Benzene

Benzene is an aromatic hydrocarbon which is present as a gas in both exhaust and evaporative emissions from motor vehicles. Benzene in the exhaust, expressed as a percentage of total organic gases (TOG), varies depending on control technology (e.g., type of catalyst) and the levels of benzene and other aromatics in the fuel, but is generally about three to five percent. The benzene fraction of evaporative emissions depends on control technology and fuel composition and characteristics (e.g., benzene level and the evaporation rate), and is generally about one percent.[74]

EPA has recently reconfirmed that benzene is a known human carcinogen by all routes of exposure.[75] Respiration is the major source of human exposure. Long-term respiratory exposure to high levels of ambient benzene concentrations has been shown to cause cancer of the tissues that form white blood cells. Among these are acute nonlymphocytic leukemia,[76] chronic lymphocytic leukemia and possibly multiple myeloma (primary malignant tumors in the bone marrow), although the evidence for the latter has decreased with more recent studies.[77,78] Leukemias, lymphomas, and other tumor types have been observed in experimental animals exposed to benzene by inhalation or oral administration. Exposure to benzene and/or its metabolites has also been linked with genetic changes in humans and animals[79] and increased proliferation of mouse bone marrow cells.[80] The occurrence of certain chromosomal changes in individuals with known exposure to benzene may serve as a marker for those at risk for contracting leukemia.[81]

A number of adverse non-cancer health effects, blood disorders such as preleukemia and aplastic anemia, have also been associated with low-dose, long-term exposure to benzene.[82] People with long-term exposure to benzene may experience harmful effects on the blood-forming tissues, especially the bone marrow. These effects can disrupt normal blood production and cause a decrease in important blood components, such as red blood cells and blood platelets, leading to anemia (a reduction in the number of red blood cells), leukopenia (a reduction in the number of white blood cells), or thrombocytopenia (a reduction in the number of blood platelets, thus reducing the ability for blood to clot). Chronic inhalation exposure to benzene in humans and animals results in pancytopenia,[83] a condition characterized by decreased numbers of circulating erythrocytes (red blood cells), leukocytes (white blood cells), and thrombocytes (blood platelets).[84,85] Individuals that develop pancytopenia and have continued exposure to benzene may develop aplastic anemia,[86] whereas others exhibit both pancytopenia and bone marrow hyperplasia (excessive cell formation), a condition that may indicate a preleukemic state.[87] [88] The most sensitive non-cancer effect observed in humans is the depression of absolute lymphocyte counts in the circulating blood.[89]

1.6.2 1,3-Butadiene

1,3-Butadiene is formed in vehicle exhaust by the incomplete combustion of fuel. It is not present in vehicle evaporative emissions, because it is not present in any appreciable amount in fuel. 1,3-Butadiene accounts for 0.4 to 1.0 percent of total organic gas exhaust, depending on control technology and fuel composition.[90]

1,3-Butadiene was classified by EPA as a Group B2 (probable human) carcinogen in 1985.[91] This classification was based on evidence from two species of rodents and epidemiologic data. In the EPA1998 draft Health Risk Assessment of 1,3-Butadiene, that was reviewed by the Science Advisory Board (SAB), the EPA proposed that 1,3-butadiene is a known human carcinogen based on human epidemiologic, laboratory animal data, and supporting data such as the genotoxicity of 1,3-butadiene metabolites.[92] The Environmental Health Committee of EPA's Scientific Advisory Board (SAB) reviewed the draft document in August 1998 and recommended that 1,3-butadiene be classified as a probable human carcinogen, stating that designation of 1,3-butadiene as a known human carcinogen should be based on observational studies in humans, without regard to mechanistic or other information.[93] In applying the 1996 Guidelines for Carcinogen Risk Assessment, the Agency relies on both observational studies in humans as well as experimental evidence demonstrating causality, and therefore the designation of 1,3-butadiene as a known human carcinogen remains applicable.[94] The Agency has revised the draft Health Risk Assessment of 1,3-Butadiene based on the SAB and public comments. The draft Health Risk Assessment of 1,3-Butadiene will undergo the Agency consensus review, during which time additional changes may be made prior to its public release and placement on the Integrated Risk Information System (IRIS).

1,3-Butadiene also causes a variety of non-cancer reproductive and developmental effects in mice and rats (no human data) when exposed to long-term, low doses of butadiene.[95] The most sensitive effect was reduced litter size at birth and at weaning. These effects were observed in studies in which male mice exposed to 1,3-butadiene were mated with unexposed females. In humans, such an effect might manifest itself as an increased risk of spontaneous abortions, miscarriages, still births, or very early deaths. Long-term exposures to 1,3-butadiene should be kept below its reference concentration of 4.0 microgram/m^3 to avoid appreciable risks of these reproductive and developmental effects.[96] EPA has developed a draft chronic, subchronic, and acute RfC values for 1,3-butadiene exposure as part of the draft risk characterization mentioned above. The RfC values will be reported on IRIS.

1.6.3 Formaldehyde

Formaldehyde is the most prevalent aldehyde in vehicle exhaust. It is formed from incomplete combustion of both gasoline and diesel fuel and accounts for one to four percent of total organic gaseous emissions, depending on control technology and fuel composition. It is not found in evaporative emissions.

Formaldehyde exhibits extremely complex atmospheric behavior.[97] It is formed by the atmospheric oxidation of virtually all organic species, including biogenic (produced by a living organism) hydrocarbons. Mobile sources contribute both primary formaldehyde (emitted directly from motor vehicles) and secondary formaldehyde (formed from photooxidation of other VOCs emitted from vehicles).

EPA has classified formaldehyde as a probable human carcinogen based on limited evidence for carcinogenicity in humans and sufficient evidence of carcinogenicity in animal studies, rats, mice, hamsters, and monkeys.[98] Epidemiological studies in occupationally exposed workers suggest that long-term inhalation of formaldehyde may be associated with tumors of the nasopharyngeal cavity (generally the area at the back of the mouth near the nose), nasal cavity, and sinus. Studies in experimental animals provide sufficient evidence that long-term inhalation exposure to formaldehyde causes an increase in the incidence of squamous (epithelial) cell carcinomas (tumors) of the nasal cavity. The distribution of nasal tumors in rats suggests that not only regional exposure but also local tissue susceptibility may be important for the distribution of formaldehyde-induced tumors.[99] Research has demonstrated that formaldehyde produces mutagenic activity in cell cultures.[100]

Formaldehyde exposure also causes a range of non-cancer health effects. At low concentrations (0.05-2.0 ppm), irritation of the eyes (tearing of the eyes and increased blinking) and mucous membranes is the principal effect observed in humans. At exposure to 1-11 ppm, other human upper respiratory effects associated with acute formaldehyde exposure include a dry or sore throat, and a tingling sensation of the nose. Sensitive individuals may experience these effects at lower concentrations. Forty percent of formaldehyde-producing factory workers reported nasal symptoms such as rhinitis (inflammation of the nasal membrane), nasal obstruction, and nasal discharge following chronic exposure.[101] In persons with bronchial asthma, the upper respiratory irritation caused by formaldehyde can precipitate an acute asthmatic attack, sometimes at concentrations below 5 ppm.[102] Formaldehyde exposure may also cause bronchial asthma-like symptoms in non-asthmatics.[103 104]

Immune stimulation may occur following formaldehyde exposure, although conclusive evidence is not available. Also, little is known about formaldehyde's effect on the central nervous system. Several animal inhalation studies have been conducted to assess the developmental toxicity of formaldehyde. The only exposure-related effect noted in these studies was decreased maternal body weight gain at the high-exposure level. No adverse effects on reproductive outcome of the fetuses that could be attributed to treatment were noted. An inhalation reference concentration (RfC), below which long-term exposures would not pose appreciable non-cancer health risks, is not available for formaldehyde at this time.

1.6.4 Acetaldehyde

Acetaldehyde is a saturated aldehyde that is found in vehicle exhaust and is formed as a result of incomplete combustion of both gasoline and diesel fuel. It is not a component of evaporative emissions. Acetaldehyde comprises 0.4 to 1.0 percent of total organic gas exhaust, depending on control technology and fuel composition.[105]

The atmospheric chemistry of acetaldehyde is similar in many respects to that of formaldehyde.[106] Like formaldehyde, it is produced and destroyed by atmospheric chemical transformation. Mobile sources contribute to ambient acetaldehyde levels both by their primary emissions and by secondary formation resulting from their VOC emissions. Acetaldehyde emissions are classified as a probable human carcinogen. Studies in experimental animals provide sufficient evidence that long-term inhalation exposure to acetaldehyde causes an increase in the incidence of nasal squamous cell carcinomas (epithelial tissue) and adenocarcinomas (glandular tissue).[107] [108]

Non-cancer effects in studies with rats and mice showed acetaldehyde to be moderately toxic by the inhalation, oral, and intravenous routes.[109] [110] [111] The primary acute effect of exposure to acetaldehyde vapors is irritation of the eyes, skin, and respiratory tract. At high concentrations, irritation and pulmonary effects can occur, which could facilitate the uptake of other contaminants. Little research exists that addresses the effects of inhalation of acetaldehyde on reproductive and developmental effects. The *in vitro* and *in vivo* studies provide evidence to suggest that acetaldehyde may be the causative factor in birth defects observed in fetal alcohol syndrome, though evidence is very limited linking these effects to inhalation exposure. Long-term exposures should be kept below the reference concentration of 9 $\mu g/m^3$ to avoid appreciable risk of these non-cancer health effects.[112]

1.6.5 Acrolein

Acrolein is extremely toxic to humans from the inhalation route of exposure, with acute exposure resulting in upper respiratory tract irritation and congestion. Although no information is available on its carcinogenic effects in humans, based on laboratory animal data, EPA considers acrolein a possible human carcinogen.[113]

1.6.6 Toluene

Toluene is a known respiratory irritant with central nervous system effects. Reproductive toxicity has been observed in exposed humans and rats.[114] Toluene toxicity is most prominent in the central nervous system after acute and chronic exposure, and that the brain is the principal target organ for toluene toxicity in humans. Specifically, recent studies indicate that toluene and other similar solvents alter the function of ion channels in neuronal membranes, including receptors stimulated by γ-amino butyric acid (GABA), *n*-methyl-D-aspartate (NMDA), nicotinic acetylcholine (nACh), and those sensitive to membrane voltage.[115, 116, 117, 118, 119] Anesthetic agents, ethanol, toluene, and other solvents inhibit the function of receptors that are excitatory in the nervous system (NMDA, nACh), and enhance the function of inhibitory receptors (GABA).[120, 121] Thus, these compounds tend to suppress the activity of the nervous system, yielding slowed reaction times, reduced arousal and, at high concentrations, anesthesia, unconsciousness and respiratory failure.[122]

1.7 Exposure to CO and Air Toxics Associated with Nonroad Engines and Vehicles

The previous section describes national-scale adverse public health effects associated with the nonroad engines and vehicles covered by this rulemaking. This section describes significant adverse health and welfare effects arising from the usage patterns of snowmobiles, large SI engines, and gasoline marine engines on the regional and local scale. Studies suggest that emissions from these engines can be concentrated in specific areas, leading to elevated ambient concentrations of particular pollutants and associated elevated exposures to operators and by-standers. This section describes these exposures.

1.7.1 Large SI Engines

Exhaust emissions from applications with significant indoor use can expose individual operators or bystanders to dangerous levels of pollution. Forklifts, ice-surfacing machines, sweepers, and carpet cleaning equipment are examples of large industrial spark-ignition engines that often operate indoors or in other confined spaces. Forklifts alone account for over half of the engines in this category. Indoor use may include extensive operation in a temperature-controlled environment where ventilation is kept to a minimum (e.g., for storing, processing, and shipping produce). Although our standards are not designed to eliminate occupational exposures, the standards will reduce CO and HC emissions that contribute to those exposures.

The principal concern for human exposure relates to CO emissions. One study showed several forklifts with measured CO emissions ranging from 10,000 to 90,000 ppm (1 to 9 percent).[123] The threshold limit value for a time-weighted average 8-hour workplace exposure set by the American Conference of Governmental Industrial Hygienists is 25 ppm.

One example of a facility that addressed exposure problems with new technology is in the apple-processing field.[124] Trout Apples in Washington added three-way catalysts to about 60 LPG-fueled forklifts to address multiple reports of employee health complaints related to CO exposure. The emission standards are based on the same technologies installed on these in-use engines.

Additional exposure concerns occur at ice rinks. Numerous papers have identified ice-surfacing machines with spark-ignition engines as the source of dangerous levels of CO and NO_2, both for skaters and for spectators.[125] This is especially problematic for skaters, who breathe air in the area where pollutant concentration is highest, with higher respiration rates resulting from their high level of physical activity. This problem has received significant attention from the medical community.

In addition to CO emissions, HC emissions from these engines can also lead to increased exposure to harmful pollutants, particularly air toxics. Since many gasoline or dual-fuel engines are in forklifts that operate indoors, reducing evaporative emissions could have direct health benefits to operators and other personnel. Fuel vapors can also cause odor problems.

1.7.2 Snowmobiles

In addition to their contribution to CO concentrations generally and visibility impairment, snowmobile emissions are of concern because of their potential impacts on riders and on park attendants, as well as other groups of people who are in contact with these vehicles for extended periods of time.

Snowmobile users can be exposed to high air toxic and CO emissions, both because they sit very close to the vehicle's exhaust port and because it is common for them to ride their vehicles in lines or groups on trails where they travel fairly close behind other snowmobiles. Because of these riding patterns, snowmobilers breathe exhaust emissions from their own vehicle, the vehicle directly in front as well as those farther up the trail. This can lead to relatively high personal exposure levels of harmful pollutants. A study of snowmobile rider CO exposure conducted at Grand Teton National Park showed that a snowmobiler riding at distances of 25 to 125 feet behind another snowmobiler and traveling at speeds from 10 to 40 mph can be exposed to average CO levels ranging from 0.5 to 23 ppm, depending on speed and distance. The highest CO level measured in this study was 45 ppm, as compared to the current 1-hour NAAQS for CO of 35 ppm.[126] While exposure levels can be less if a snowmobile drives 15 feet off the centerline of the lead snowmobile, the exposure levels are still of concern. This study led to the development of an empirical model for predicting CO exposures from riding behind snowmobiles.

Hydrocarbon speciation for snowmobile emissions was performed for the State of Montana in a 1997 report.[127] Using the dispersion model for CO from the Grand Teton exposure study with air toxic emission rates from the State of Montana's emission study, average benzene exposures for riders driving at an average speed of 23 mph, 25 feet behind another snowmobile were predicted to be 0.402 ppm, (95% bootstrap confidence intervals = 0.285-0.555). Average toluene concentrations in this scenario were modeled at 10.3 ppm (95% bootstrap CI = 8.1-12.8). With an average speed of 23 mph with a 50 foot space between snowmobiles, average benzene concentrations were estimated to be 0.210 ppm (95% bootstrap CI = 0.154 – 0.271).

The cancer risk posed to those exposed to benzene emissions from snowmobiles must be viewed within the broader context of expected lifetime benzene exposure. Observed monitoring data and predicted modeled values demonstrate that a significant cancer risk already exists from ambient concentrations of benzene for a large portion of the US population. The Agency's 1996 National-Scale Air Toxics Assessment of personal exposure to ambient concentrations of air toxic compounds emitted by outside sources (e.g., cars and trucks, power plants) found that benzene was among the five air toxics appear to pose the greatest risk to people nationwide. This national assessment found that for approximately 50% of the US population in 1996, the inhalation cancer risks associated with benzene exceeded 10 in one million. Modeled predictions for ambient benzene from this assessment correlated well with observed monitored concentrations of benzene ambient concentrations.

Specifically, the draft National-Scale Assessment predicted nationwide annual average benzene exposures from outdoor sources to be 1.4 µg/m3.[128] In comparison, snowmobile riders and those directly exposed to snowmobile exhaust emissions had predicted benzene levels two to three orders of magnitude greater than the 1996 national average benzene concentrations.[129] These elevated levels are also known as air toxic "hot spots," which are of particular concern to the Agency. Thus, total annual average exposures to typical ambient benzene concentrations combined with elevated short-term exposures to benzene from snowmobiles may pose a significant risk of adverse public health effects to snowmobile riders and those exposed to exhaust benzene emissions from snowmobiles.

Toluene concentrations, also elevated in snowmobile plumes, were predicted to be within the concentrations typically observed in occupational settings. While not considered a human carcinogenic hazard, toluene at high concentrations can affect the central nervous system, causing effects similar to intoxication. Weakness, confusion, euphoria, dizziness, and headache are associated with high exposures to toluene. National Institute of Occupational Safety and Health. NIOSH Pocket Guide to Chemical Hazards. NIOSH web site. http://www.cdc.gov/niosh/npg/npgd0619.html. Exposure to constituents of snowmobile exhaust at the levels predicted is anticipated to cause such effects in the human central nervous system.

Since snowmobile riders often travel in large groups, the riders towards the back of the group are exposed to the accumulated exhaust of those riding ahead. This scenario was not modeled, given the lack of data on snowmobile plume concentrations in trains of several vehicles. However, snowmobile trains, consisting of multiple riders in a line, are common riding scenarios. In these conditions, exhaust concentrations are anticipated to be significantly higher than those predicted here. These exposure levels can continue for hours at a time, depending on the length of a ride. An additional consideration is that the risk to health from CO exposure increases with altitude, especially for unacclimated individuals. Therefore, a park visitor who lives at sea level and then rides his or her snowmobile on trails at high-altitude is more susceptible to the effects of CO than local residents.

In addition to snowmobilers themselves, people who are active in proximity to the areas where snowmobilers congregate may also be exposed to high CO levels. An OSHA industrial hygiene survey reported a peak CO exposure of 268 ppm for a Yellowstone employee working at an entrance kiosk where snowmobiles enter the park. This level is greater than the NIOSH peak recommended exposure limit of 200 ppm. OSHA's survey also measured employees' exposures to several air toxics. Benzene exposures in Yellowstone employees ranged from 67-600 µg/m3, with the same individual experiencing highest CO and benzene exposures. The highest benzene exposure concentrations exceeded the NIOSH Recommended Exposure Limit of 0.1 ppm for 8-hour exposures.

Notes to Chapter 1

1.Carbon monoxide also participates in the production of ozone, albeit at a much slower rate than most VOC and NOx compounds.

2.U.S. EPA, 1996, Review of National Ambient Air Quality Standards for Ozone, Assessment of Scientific and Technical Information, OAQPS Staff Paper, EPA-452/R-96-007. A copy of this document can be obtained from Air Docket A-99-06, Document No. II-A-22.

3.U.S. EPA, 1996, Air Quality Criteria for Ozone and Related Photochemical Oxidants, EPA/600/P-93/004aF. The document is available on the internet at http://www.epa.gov/ncea/ozone.htm. A copy can also be obtained from Air Docket No. A-99-06, Documents Nos. II-A-15, II-A-16, II-A-17.

4.National Air Quality and Emissions Trends Report, 1999, EPA, 2001, at Table A-19. This document is available at http://www.epa.gov/oar/aqtrnd99/. The data from the Trends report are the most recent EPA air quality data that has been quality assured. A copy of this table can also be found in Docket No. A-2000-01, Document No. II-A-64.

5.National Air Quality and Emissions Trends Report, 1998, March, 2000, at 28. This document is available at http://www.epa.gov/oar/aqtrnd98/. Relevant pages of this report can be found in Memorandum to Air Docket A-2000-01 from Jean Marie Revelt, September 5, 2001, Document No. II-A-63.

6.National Air Quality and Emissions Trends Report, 1998, March, 2000, at 32. This document is available at http://www.epa.gov/oar/aqtrnd98/. Relevant pages of this report can be found in Memorandum to Air Docket A-2000-01 from Jean Marie Revelt, September 5, 2001, Document No. II-A-63.

7.Additional information about this modeling can be found in our Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, document EPA420-R-00-026, December 2000. Docket No. A-2000-01, Document No. II-A-13. This document is also available at http://www.epa.gov/otaq/diesel.htm#documents.

8.We also performed ozone air quality modeling for the western United States but, as described further in the air quality technical support document, model predictions were well below corresponding ambient concentrations for out heavy-duty engine standards and fuel sulfur control rulemaking. Because of poor model performance for this region of the country, the results of the Western ozone modeling were not relied on for that rule.

9.U.S. EPA Regulatory Impact Analysis – Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements. EPA420-R-99-023. December 1999. A copy of this document is also available in Docket A-97-10, Document No. V-B-01.

10.Additional information about these studies can be found in Chapter 2 of "Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements," December 2000, EPA420-R-00-026. Docket No. A-2000-01, Document Number II-A-13. This document is also available at http://www.epa.gov/otaq/diesel.htm#documents.

11.Air Quality Criteria Document for Ozone and Related Photochemical Oxidants, EPA National Center for Environmental Assessment, July 1996, Report No. EPA/600/P-93/004cF. The document is available on the internet at http://www.epa.gov/ncea/ozone.htm. A copy can also be obtained from Air Docket No. A-99-06, Documents Nos. II-A-15, II-A-16, II-A-17.

12.A copy of this data can be found in Air Docket A-2000-01, Document No.II-A-80.

13.Memorandum to Docket A-99-06 from Eric Ginsburg, EPA, "Summary of Model-Adjusted Ambient Concentrations for Certain Levels of Ground-Level Ozone over Prolonged Periods," November 22, 2000. Docket A-2000-01, Document Number II-B-13.

14.Memorandum to Docket A-99-06 from Eric Ginsburg, EPA, "Summary of Model-Adjusted Ambient Concentrations for Certain Levels of Ground-Level Ozone over Prolonged Periods," November 22, 2000, at Table C, Control Scenario – 2020 Populations in Eastern Metropolitan Counties with Predicted Daily 8-Hour Ozone greater than or equal to 0.080 ppm. Docket A-2000-01, Document Number II-B-13.

15.U.S. EPA, 1995, Review of National Ambient Air Quality Standards for Nitrogen Dioxide, Assessment of Scientific and Technical Information, OAQPS Staff Paper, EPA-452/R-95-005.

16.U.S.EPA, 1993, Air Quality Criteria for Oxides of Nitrogen, EPA/600/8-91/049aF.

17.Much of the information in this subsection was excerpted from the EPA document, *Human Health Benefits from Sulfate Reduction*, written under Title IV of the 1990 Clean Air Act Amendments, U.S. EPA, Office of Air and Radiation, Acid Rain Division, Washington, DC 20460, November 1995. Air Docket A-2000-01, Document No. II-A-32.

18.Vitousek, Peter M., John Aber, Robert W. Howarth, Gene E. Likens, et al. 1997. Human Alteration of the Global Nitrogen Cycle: Causes and Consequences. *Issues in Ecology*. Published by Ecological Society of America, Number 1, Spring 1997.

19. National Research Council, 1993. Protecting Visibility in National Parks and Wilderness Areas. National Academy of Sciences Committee on Haze in National Parks and Wilderness Areas. National Academy Press, Washington, DC. This document is available on the internet at http://www.nap.edu/books/0309048443/html/

20.Much of this information was taken from the following EPA document: *Deposition of Air Pollutants to the Great Waters-Second Report to Congress*, Office of Air Quality Planning and

Standards, June 1997, EPA-453/R-97-011.

21.Terrestrial nitrogen deposition can act as a fertilizer. In some agricultural areas, this effect can be beneficial.

22. Coburn, R.F. (1979) Mechanisms of carbon monoxide toxicity. *Prev. Med.* 8:310-322.

23. Helfaer, M.A., and Traystman, R.J. (1996) Cerebrovascular effects of carbon monoxide. In: *Carbon Monoxide* (Penney, D.G., ed). Boca Raton, CRC Press, 69-86.

24. Benignus, V.A. (1994) Behavioral effects of carbon monoxide: meta analyses and extrapolations. *J. Appl. Physiol.* 76:1310-1316. Docket A-2000-01, Document IV-A-127.

25. Rowe, B., Milner, R., Johnson, C. Bota, G. Snowmobile-Related Deaths in Ontario: A 5-Year Review. *Canadian Medical Association Journal*, Vol. 146, Issue 2, pp 147-152. Docket A-2000-01, Document IV-A-194.

26.The CO Criteria Document (EPA 600/P-99/001F) contains additional information about the health effects of CO, human exposure, and air quality. It was published as a final document and made available to the public in August 2000 (www.epa.gov/ncea/co/). A copy of this document is also available in Docket A-2000-01, Document A-II-29.

27.National Air Quality and Emissions Trends Report, 1999, EPA, 2001, at Table A-19. This document is available at http://www.epa.gov/oar/aqtrnd99/. The data from the Trends report are the most recent EPA air quality data that has been quality assured. A copy of this table can also be found in Docket No. A-2000-01, Document No. II-A-64.

28. Information attached to written comments, P. Amette, Vice President, Motorcycle Industry Council, Incorporated. Docket A-2000-01, Document IV-D-214.

29. Economic Contribution of Off-Highway Vehicle Use in Colorado" Prepared for the Colorado Of-Highway Vehicle Coalition, by Hazen and Sawer Environmental Engineers & Scientists. July, 2001. Colorado OHV User Survey" Summary of Results: prepared for State of Colorado OHV Coalition under a contract with the Colorado State Parks OHV Program, prepared by T. Crimins, Trails Consultant. January 1999. Off Highway Vehicle Uses and Owners Preferences in Uta", prepared for Utah DNR, Div. Of Parks and recreation, prepared by Institute for Outdoor recreation and Tourism Department of Forest Resources, Utah State University. July 22, 2001. These documents are available in Docket A-2000-01, Documents IV-A-02, 03, 05.

30. Off Highway Vehicle Uses and Owners Preferences in Uta", prepared for Utah DNR, Div. Of Parks and recreation, prepared by Institute for Outdoor recreation and Tourism Department of Forest Resources, Utah State University. July 22, 2001. This document is available in Docket A-2000-01, Document IV-A-03.

31. All-Terrain Vehicle Exposure, Injury, Death and Risk Studies. U.S. Consumer Product Safety Commission, April, 1998. Docket A-2000-01, Document IV-A-197.

32. Anchorage Carbon Monoxide Emission Inventory and Year 2000 Attainment Projections" Air Quality Program, Environmental Services Division, Department of Health and Human Services [DRAFT]. May, 2001. Docket A-2000-01, Document II-A-40.

33.Areas with a few years of attainment data can and often do have exceedances following such years of attainment because of several factors including different climatic events during the later years, increases in inventories, etc. Thus, a plan to maintain the NAAQS is critical to showing attainment.

34.Dulla, Robert G. Sierra Research, Inc. "A Review of Vehicle Test Programs Conducted in Alaska in Recent Years and a Summary of the Fairbanks Co. Inventory 1995-2001. June 4, 2001. Docket A-2000-01, Document IV-A-198.

35.St. Paul, Minnesota was recently reclassified as being in attainment but is still considered a maintenance area. There is also a significant population of snowmobiles in Minnesota, with snowmobile trails in Washington County.

36.The trail maps consulted for this rulemaking can be found in Docket No. A-2000-01, Document No. II-A-65.

37. Written comments from J.S. Grumet, Executive Director, Northeast States for Coordinated Use Management (NESCAUM), Docket A-2000-01, Document IV-D-196.

38. Doss, Howard. Snowmobile Safety. Michigan Agricultural Safety Health Center. A copy of this document can be found in Docket A-2000-01, Document IV-A-148 (an attachment).

39. Mauer, Richard. "Snowmobile Perils" Anchorage Daily News. Internet search 7/3/02. Docket A-2000-01, IV-A-184.

40.Dulla, Robert G. Sierra Research, Inc. "A Review of Vehicle Test Programs Conducted in Alaska in Recent Years and a Summary of the Fairbanks Co. Inventory 1995-2001. June 4, 2001. Docket A-2000-01, Document IV-A-198.

41. Technical Memorandum to Docket A-2000-01 from Drew Kodjak, Attorney-Advisor, Office of Transportation and Air Quality, "Air Quality Information for Selected CO Nonattainment Areas," July 27, 2001, Docket Number A-2000-01, Document Number II-B-18.

42. Air Quality Criteria for Carbon Monoxide, US EPA, EPA 600/P-99/001F, June 2000, at 3-38, Figure 3-32 (Federal Bldg, AIRS Site 020900002). Air Docket A-2000-01, Document

Number II-A-29. This document is also available at http://www.epa.gov/ncea/coabstract.htm.

43.National Research Council. The Ongoing Challenge of Managing Carbon Monoxide Pollution in Fairbanks, AK. May 2002. Docket A-2000-01, Document IV-A-115.

44. National Air Quality and Emissions Trends Report, 1999, EPA, 2001, at Table A-19. This document is available at http://www.epa.gov/oar/aqtrnd99/. The data from the Trends report are the most recent EPA air quality data that have been quality assured. A copy of this table can also be found in Docket No. A-2000-01, Document No. II-A-64. See also the air quality update, 1998-2000 Ozone and 1999-2000 Carbon Monoxide, available at www.epa.gov/oar/aqtrnd00. A copy of this document is also available at Docket A-2000-01, Document No. IV-A-141.

45. Air Quality and Emissions Trends Report, 1998, March, 2000. This document is available at http://www.epa.gov/oar/aqtrnd98/. Relevant pages of this report can be found in Memorandum to Air Docket A-2000-01 from Jean Marie Revelt, September 5, 2001, Document No. II-A-63.

46.EPA (1996) Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information OAQPS Staff Paper. EPA-452/R-96-013. Docket Number A-99-06, Documents Nos. II-A-18, 19, 20, and 23. The particulate matter air quality criteria documents are also available at http://www.epa.gov/ncea/partmatt.htm.

47.Additional information about the Regulatory Model System for Aerosols and Deposition (REMSAD) and our modeling protocols can be found in our Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, document EPA420-R-00-026, December 2000. Docket No. A-2000-01, Document No. A-II-13. This document is also available at http://www.epa.gov/otaq/disel.htm#documents.

48.Memorandum to Docket A-99-06 from Eric O. Ginsburg, Senior Program Advisor, “Summary of 1999 Ambient Concentrations of Fine Particulate Matter,” November 15, 2000. Air Docket A-2000-01, Document No. II-B-12.

49.Memorandum to Docket A-99-06 from Eric O. Ginsburg, Senior Program Advisor, “Summary of Absolute Modeled and Model-Adjusted Estimates of Fine Particulate Matter for Selected Years,” December 6, 2000. This memo is also available in the docket for this rule. Docket A-2000-01, Document Number II-B-14.

50.The fine particle monitoring network was expanding with more monitors being added between 1996 and 2002.

51. Technical Memorandum, EPA Air Docket A-99-06, Eric O. Ginsburg, Senior Program Advisor, Emissions Monitoring and Analysis Division, OAQPS, Summary of Absolute Modeled and Model-Adjusted Estimates of Fine Particulate Matter for Selected Years, December 6, 2000, Table P-2. Docket Number 2000-01, Document Number II-B-14.

52.National Research Council, 1993 (Ibid); U.S. EPA Criteria for Particulate Matter, 8-3; US EPA Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information OAQPS Staff Paper. EPA-452/R-96-013. 1996. Docket Number A-99-06, Documents Nos. II-A-18, 19, 20, and 23. The particulate matter air quality criteria documents are also available at http://www.epa.gov/ncea/partmatt.htm.

53. Council on Environmental Quality, 1978. Visibility Protection for Class I Areas, the Technical Basis. Washington DC. Cited in US EPA, Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information. OAQPS Staff Paper. EPA-452 \ R-96-013. This document is available in Docket A-99-06, Document II-A-23.

54. Sisler, James F. Spatial and Seasonal Patterns and Long Term Variability of the Composition of Haze in the United States: An Analysis of Data from the IMPROVE Network. 1996. A copy of the relevant pages of this document can be found in Docket A-99-06, Document No. II-B-21.

55. National Research Council, 1993 (Ibid).

56.National Research Council, 1993 (Ibid).

57. National Acid Precipitation Assessment Program (NAPAP), 1991. Office of the Director. Acid Deposition: State of Science and Technology. Report 24, Visibility: Existing and Historical Conditions - Causes and Effects. Washington, DC. Cited in US EPA, Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information. OAQPS Staff Paper. EPA-452 \ R-96-013. This document is available in Docket A-99-06, Document II-A-23. Also, US EPA. Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information, OAQPS Staff Paper. Preliminary Draft. June 2001. Docket A-2000-01, Document IV-A-199.

58.Memorandum to Docket A-99-06 from Eric O. Ginsburg, Senior Program Advisor, “Summary of 1999 Ambient Concentrations of Fine Particulate Matter,” November 15, 2000. Air Docket A-2000-01, Document No. II-B-12.

59. Technical Memorandum, EPA Air Docket A-99-06, Eric O. Ginsburg, Senior Program Advisor, Emissions Monitoring and Analysis Division, OAQPS, Summary of Absolute Modeled and Model-Adjusted Estimates of Fine Particulate Matter for Selected Years, December 6, 2000, Table P-2. Docket Number 2000-01, Document Number II-B-14.

60. The trail maps consulted for this rulemaking can be found in Docket No. A-2000-01, Document No. II-A-65.

61.This goal was recently upheld by the US Court of Appeals. American Corn Growers Association v. EPA, 291F.3d 1(D.C .Cir 2002). A copy of this decision can be found in Docket A-2000-01, Document IV- A-113..

62.U.S. EPA Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information OAQPS Staff Paper. EPA-452/R-96-013. 1996. Docket Number A-99-06, Documents Nos. II-A-18, 19, 20, and 23. The particulate matter air quality criteria documents are also available at http://www.epa.gov/ncea/partmatt.htm.

63. Chestnut, L.G., and R.D. Rowe. 1990a. *Preservation for Visibility Protection at the National Parks: Draft Final Report*. Prepared for Office of Air Quality Planning and Standards, US Environmental Protection Agency, and Air Quality Management Division, National Park Service; Chestnut, L.G., and R.D. This document is available from Docket A-97-10, Document II-A-33 Rowe. 1990b. A New National Park Visibility Value Estimates. In *Visibility and Fine Particles*, Transactions of an AWMA/EPA International Speciality Conference. C.V. Mathai, ed., Air and Waste Management Association, Pittsburg. Docket A-2000-01, IV-A-2000.

64.Letter from Debra C. Miller, Data Analyst, National Park Service, to Drew Kodjak, August 22, 2001. Docket No. A-2000-01, Document Number. II-B-28.

65.Technical Memorandum, Aaron Worstell, Environmental Engineer, National Park Service, Air Resources Division, Denver, Colorado, particularly Table 1. Docket No. A-2000-01, Document Number II-G-178.

66.Letter from Debra C. Miller, Data Analyst, National Park, to Drew Kodjak, August 22, 2001. Docket No. A-2000-01, Document Number. II-B-28.

67.Letter from Debra C. Miller, Data Analyst, National Park Service, to Drew Kodjak, August 22, 2001. Docket No. A-2000-01, Document. Number. II-B-28.

68.National Park Service, February 2000. Air Quality Concerns Related to Snowmobile Usage in National Parks. Air Docket A-2000-01, Document No. II-A-44.

69.G. Bishop, et al., Snowmobile Contributions to Mobile Source Emissions in Yellowstone National Park, Environmental Science and Technology, Vol. 35, No. 14, at 2873. Docket No. A-2000-01, Document No. II-A-47.

70.Memorandum to IV-D-204 at 13

71.Ibid, at 14.

72.Julia Rege, Environmental Scientist, EPA. Memorandum to Docket A-2000-0. Predicted visibility effects from snowmobile exhaust (particulate matter) on or near snowmobile trails in Yellowstone National Park. July, 12, 2002. Docket A-2000-01, Document IV-A-147.

73.See our Mobile Source Air Toxics final rulemaking, 66 FR 17230, March 29, 2001, and the Technical Support Document for that rulemaking. Docket No. A-2000-01, Documents Nos. II-A-42 and II-A-30.

74.U.S. EPA. (1999) Analysis of the Impacts of Control Programs on Motor Vehicle Toxic Emissions and Exposure in Urban Areas and Nationwide: Volume I. Prepared for EPA by Sierra Research, Inc. and Radian International Corporation/Eastern Research Group, November 30, 1999. Report No. EPA420-R-99-029. http://www.epa.gov/otaq/toxics.htm.

75.U.S. EPA (1998) Environmental Protection Agency, Carcinogenic Effects of Benzene: An Update, National Center for Environmental Assessment, Washington, DC. 1998. EPA/600/P-97/001F. http://www.epa.gov/ncepihom/Catalog/EPA600P97001F.html.

76.Leukemia is a blood disease in which the white blood cells are abnormal in type or number. Leukemia may be divided into nonlymphocytic (granulocytic) leukemias and lymphocytic leukemias. Nonlymphocytic leukemia generally involves the types of white blood cells (leukocytes) that are involved in engulfing, killing, and digesting bacteria and other parasites (phagocytosis) as well as releasing chemicals involved in allergic and immune responses. This type of leukemia may also involve erythroblastic cell types (immature red blood cells). Lymphocytic leukemia involves the lymphocyte type of white bloods cell that are responsible for the immune responses. Both nonlymphocytic and lymphocytic leukemia may, in turn, be separated into acute (rapid and fatal) and chronic (lingering, lasting) forms. For example; in acute myeloid leukemia (AML) there is diminished production of normal red blood cells (erythrocytes), granulocytes, and platelets (control clotting) which leads to death by anemia, infection, or hemorrhage. These events can be rapid. In chronic myeloid leukemia (CML) the leukemic cells retain the ability to differentiate (i.e., be responsive to stimulatory factors) and perform function; later there is a loss of the ability to respond.

77.U.S. EPA (1985) Environmental Protection Agency, Interim quantitative cancer unit risk estimates due to inhalation of benzene, prepared by the Office of Health and Environmental Assessment, Carcinogen Assessment Group, Washington, DC. for the Office of Air Quality Planning and Standards, Washington, DC., 1985. Air Docket A-2000-01, Document No. II-A-74.

78.Clement Associates, Inc. (1991) Motor vehicle air toxics health information, for U.S. EPA Office of Mobile Sources, Ann Arbor, MI, September 1991. Air Docket A-2000-01, Document No. II-A-49.

79.International Agency for Research on Cancer (IARC) (1982) IARC monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 29, Some industrial chemicals and dyestuffs, International Agency for Research on Cancer, World Health Organization, Lyon, France, p. 345-389.

80.Irons, R.D., W.S. Stillman, D.B. Colagiovanni, and V.A. Henry (1992) Synergistic action of the benzene metabolite hydroquinone on myelopoietic stimulating activity of granulocyte/macrophage colony-stimulating factor *in vitro*, Proc. Natl. Acad. Sci. 89:3691-3695.

81.Lumley, M., H. Barker, and J.A. Murray (1990) Benzene in petrol, *Lancet* 336:1318-1319.

82.U.S. EPA (1993) Motor Vehicle-Related Air Toxics Study, U.S. Environmental Protection Agency, Office of Mobile Sources, Ann Arbor, MI, EPA Report No. EPA 420-R-93-005, April 1993.

83.Pancytopenia is the reduction in the number of all three major types of blood cells (erythrocytes, or red blood cells, thrombocytes, or platelets, and leukocytes, or white blood cells). In adults, all three major types of blood cells are produced in the bone marrow of the vertebra, sternum, ribs, and pelvis. The bone marrow contains immature cells, known as multipotent myeloid stem cells, that later differentiate into the various mature blood cells. Pancytopenia results from a reduction in the ability of the red bone marrow to produce adequate numbers of these mature blood cells.

84.Aksoy, M (1991) Hematotoxicity, leukemogenicity and carcinogenicity of chronic exposure to benzene. In: Arinc, E.; Schenkman, J.B.; Hodgson, E., Eds. Molecular Aspects of Monooxygenases and Bioactivation of Toxic Compounds. New York: Plenum Press, pp. 415-434.

85.Goldstein, B.D. (1988) Benzene toxicity. Occupational medicine. State of the Art Reviews. 3: 541-554.

86.Aplastic anemia is a more severe blood disease and occurs when the bone marrow ceases to function, i.e.,these stem cells never reach maturity. The depression in bone marrow function occurs in two stages - hyperplasia, or increased synthesis of blood cell elements, followed by hypoplasia, or decreased synthesis. As the disease progresses, the bone marrow decreases functioning. This myeloplastic dysplasia (formation of abnormal tissue) without acute leukemiais known as preleukemia. The aplastic anemia can progress to AML (acute mylogenous leukemia).

87.Aksoy, M., S. Erdem, and G. Dincol. (1974) Leukemia in shoe-workers exposed chronically to benzene. Blood 44:837.

88.Aksoy, M. and K. Erdem. (1978) A follow-up study on the mortality and the development of leukemia in 44 pancytopenic patients associated with long-term exposure to benzene. Blood 52: 285-292.

89.Rothman, N., G.L. Li, M. Dosemeci, W.E. Bechtold, G.E. Marti, Y.Z. Wang, M. Linet, L.Q. Xi, W. Lu, M.T. Smith, N. Titenko-Holland, L.P. Zhang, W. Blot, S.N. Yin, and R.B. Hayes (1996) Hematotoxicity among Chinese workers heavily exposed to benzene. Am. J. Ind. Med. 29: 236-246.

90.U.S. EPA. (1999) Analysis of the Impacts of Control Programs on Motor Vehicle Toxic Emissions and Exposure in Urban Areas and Nationwide: Volume I. Prepared for EPA by Sierra Research, Inc. and Radian International Corporation/Eastern Research Group, November 30, 1999. Report No. EPA420-R-99-029. http://www.epa.gov/otaq/toxics.htm.

91.U.S. EPA (1985) Mutagenicity and Carcinogenicity Assessment of 1,3-Butadiene. EPA/600/8-85/004F. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. Washington, DC.

92.U.S. EPA (1998) Draft Health Risk Assessment of 1,3-Butadiene, National Center for Environmental Assessment, Office of Research and Development, U.S. EPA, EPA/600/P-98/001A, February 1998.

93.Scientific Advisory Board. 1998. An SAB Report: Review of the Health Risk Assessment of 1,3-Butadiene. EPA-SAB-EHC-98, August, 1998.

94.EPA 1996. guidelines for carcinogen risk assessment. Federal Register 61(79):17960-18011.

95.U.S. EPA (1985) Mutagenicity and carcinogenicity assessment of 1,3-butadiene. EPA/600/8-85/004F. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. Washington, DC. http://www.epa.gov/ngispgm3/iris/subst/0139.htm.

96.U.S. EPA (1985) Mutagenicity and carcinogenicity assessment of 1,3-butadiene. EPA/600/8-85/004F. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. Washington, DC. http://www.epa.gov/ngispgm3/iris/subst/0139.htm.

97.Ligocki, M.P., G.Z. Whitten, R.R. Schulhof, M.C. Causley, and G.M. Smylie (1991) Atmospheric transformation of air toxics: benzene, 1,3-butadiene, and formaldehyde, Systems Applications International, San Rafael, CA (SYSAPP-91/106).

98.U.S. EPA (1987) Environmental Protection Agency, Assessment of health risks to garment workers and certain home residents from exposure to formaldehyde, Office of Pesticides and Toxic Substances, April 1987. Air Docket A-2000-01, Document No. II-A-48.

99.Clement Associates, Inc. (1991) Motor vehicle air toxics health information, for U.S. EPA Office of Mobile Sources, Ann Arbor, MI, September 1991. Air Docket A-2000-01, Document No. II-A-49.

100.U.S. EPA (1993) Motor Vehicle-Related Air Toxics Study, U.S. Environmental Protection Agency, Office of Mobile Sources, Ann Arbor, MI, EPA Report No. EPA 420-R-93-005, April 1993. http://www.epa.gov/otaq/toxics.htm.

101.Wilhelmsson, B. and M. Holmstrom. (1987) Positive formaldehyde PAST after prolonged formaldehyde exposure by inhalation. *The Lancet*:164.

102.Burge, P.S., M.G. Harries, W.K. Lam, I.M. O'Brien, and P.A. Patchett. (1985) Occupational asthma due to formaldehyde. *Thorax* 40:225-260.

103.Hendrick, D.J., R.J. Rando, D.J. Lane, and M.J. Morris (1982) Formaldehyde asthma: Challenge exposure levels and fate after five years. *J. Occup. Med*. 893-897.

104.Nordman, H., H. Keskinen, and M. Tuppurainen. (1985) Formaldehyde asthma - rare or overlooked? *J. Allergy Clin. Immunol*. 75:91-99.

105.U.S. EPA. (1999) Analysis of the Impacts of Control Programs on Motor Vehicle Toxic Emissions and Exposure in Urban Areas and Nationwide: Volume I. Prepared for EPA by Sierra Research, Inc. and Radian International Corporation/Eastern Research Group, November 30, 1999. Report No. EPA420-R-99-029. http://www.epa.gov/otaq/toxics.htm

106.Ligocki, M.P., G.Z. Whitten (1991) Atmospheric transformation of air toxics: acetaldehyde and polycyclic organic matter, Systems Applications International, San Rafael, CA, (SYSAPP-91/113).

107. Environmental Protection Agency, Health assessment document for acetaldehyde, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC, EPA-600/8-86/015A (External Review Draft), 1987. Air Docket A-2000-01, Document No. II-A-33.

108.Environmental Protection Agency, Integrated Risk Information System (IRIS), Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH, 1992. Acetaldehyde. http://www.epa.gov/iris/subst/0290.htm

109.U.S. EPA (1987) Health Assessment Document for Acetaldehyde — External Review Draft. Office of Health and Environmental Assessment, Research Triangle Park, NC. Report No. EPA 600/8-86/015A.

110.California Air Resources Board (CARB) (1992) Preliminary Draft: Proposed identification of acetaldehyde as a toxic air contaminant, Part B Health assessment, California Air Resources Board, Stationary Source Division, August, 1992. Air Docket A-2000-01, Document No. II-A-34.

111.U.S. EPA (1997) Environmental Protection Agency, Integrated Risk Information System (IRIS), Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH, 1997. Acetaldehyde. http://www.epa.gov/iris/subst/0290.htm

112.U.S. EPA (1999) Environmental Protection Agency, Integrated Risk Information System (IRIS), Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH. 1,3-Butadiene. http://www.epa.gov/iris/subst/0139.htm .

113.U.S. EPA (1993) Environmental Protection Agency, Integrated Risk Information System (IRIS), Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH. Acrolein http://www.epa.gov/iris/subst/0364.htm .

114. U.S. EPA Integrated Risk Information System (IRIS) summary for Toluene. Www.epa.gov/iris/subst/0118.htm

115. Peoples, R.W., Li, C., and Weight, F.F. (1996) Lipid vs. protein theories of alcohol action in the nervous system. *Annu. Rev. Pharmacol. Toxicol.* 36:185-201.

116. Beckstead, M.J., Weiner, J.L., Eger, E.I. II, Gong, D.H. and Mihic, S.J. (2000) Glycine and ã-aminobutyric acid$_A$ receptor function is enhanced by inhaled drugs of abuse. *Mol. Pharm.* 57:1199-1205.

117. Cruz, S.L., R.L. Balster, and J.J. Woodward. 2000. Effects of volatile solvents on recombinant N-methyl-D-aspartate receptors expressed in Xenopus oocytes. Brit. J. Pharmacol. 131:1303-1308. Cruz, S.L., T. Mirshahi, B. Thomas, R.L. Balster and J.J. Woodward. 1998. Effects of the abused solvent toluene on recombinant N-methyl-D-aspartate and non-N-methyl-D-aspartate receptors expressed in Xenopus oocytes. J. Pharmacol. Exp. Ther. 286:334-40. Both of these documents are cited in Benignus, V., Bushnell, P. and Boyes, W. "Acute Behavioral Effects of Exposure to Toluene and Carbon Monoxide from Snowmobile Exhaust" Docket A-2000-01, Document IV-A-143.

118. Bale, A.S., Cruz, S.L., Balster, R.L., and Woodward, J.J. Effects of Toluene on Nicotinic Acetylcholine Receptors Expressed in Xenopus Oocytes. Presented at the Sixty-First Annual College on Problems of Drug Dependence, Acapulco, Mexico, 1999. This document is cited in Benignus, V., Bushnell, P. and Boyes, W. "Acute Behavioral Effects of Exposure to Toluene and Carbon Monoxide from Snowmobile Exhaust" Docket A-2000-01, Document IV-A-143.

119. Tillar, R., Shafer, T.J. and Woodward, J.J. (2002) Toluene inhibits voltage-sensitive calcium channels expressed in pheochromocytoma cells. *Neurochemistry International*, in press.

120. Danysz, W., W. Dyr, E. Jankowska, S. Glazewski, W. Kostowski. The involvement of NMDA receptors in acute and chronic effects of ethanol. Alcohol. Clin. Exp. Res. 16:499-504, 1992. This document is cited in Benignus, V., Bushnell, P. and Boyes, W. "Acute Behavioral Effects of Exposure to Toluene and Carbon Monoxide from Snowmobile Exhaust" Docket A-2000-01, Document IV-A-143.; Tassonyi, E., Charpantier, E., Muller, D., Dumont, L. and Bertrand, D. (2002 The role of nicotinic acetylcholine receptors in the mechanisms of anesthesia. *Brain Res. Bull.* 57:133-150.

121.Mihic, S.J., McQuilkin, S.J., Eger, E.I. II, Ionescu, P. and Harris, R.A. (1994) Potentiation of ã-aminobutyric acid type A receptor-mediated chloride currents by novel halogenated compounds correlates with their abilities to induce general anesthesia. *Mol. Pharm.* 46:851-857. Olsen, R.W. (1998) The molecular mechanism of action of general anesthetics: Structural aspects of interactions with GABA$_A$ receptors. *Toxicol. Lett.* 100-101:193-201.

122. Balster, R.L. (1998) Neural basis of inhalant abuse. *Drug Alc. Dependence* 51:207-214.

123."Warehouse Workers' Headache, Carbon Monoxide Poisoning from Propane-Fueled Forklifts," Thomas A. Fawcett, et al, *Journal of Occupational Medicine*, January 1992, p. 12. Docket A-2000-01, Document No. II-A-36.

124.“Terminox System Reduces Emissions from LPG Lift Trucks,” Material Handling Product News. Docket A-2000-01, Document No. II-A-14.

125.Summary of Medical Papers Related to Exhaust Emission Exposure at Ice Rinks,” EPA Memorandum from Alan Stout to Docket A-2000-01. Docket A-2000-01, Document No. II-A-38.

126. Snook and Davis, 1997, “An Investigation of Driver Exposure to Carbon Monoxide While Traveling Behind Another Snowmobile.” Docket No. A-2000-01, Document Number II-A-35.

127. Emissions from Snowmobile Engines Using Bio-based Fuels and Lubricants, Southwest Research Institute, August, 1997, at 22. Docket No. A-2000-01, Document Number II-A-50.

128. National-Scale Air Toxics Assessment for 1996, EPA-453/R-01-003, Draft, January 2001.

129. Technical Memorandum, Chad Bailey, Predicted benzene exposures and ambient concentrations on and near snowmobile trails, August 17, 2001. Air Docket A-2000-01, Document No. II-B-27.

Chapter 2: Industry Characterization

To accurately assess the potential impact of this emission control program, it is important to understand the nature of the affected industries. This chapter describes relevant background information related to each of the categories of engines and vehicles subject to this proposal. For each engine category, descriptions of the supply and demand sides of the markets are provided. Additionally, industry organization and historical market trends data are discussed.

2.1 CI Marine Engines and Recreational Boats

This section gives a general characterization of the segments of the marine industry that may be affected by the regulation. The emission control program may affect diesel marine engines and recreational boats that contain these engines. We therefore focus on the compression-ignition (CI) diesel marine engine manufacturing and recreational boat building industries. Information is also provided for several spark-ignition vessel categories, even though they are not directly affected by this rule (spark-ignition engines and vessels are the subject of a separate proposed rulemaking regarding evaporative emissions; See 67 FR 53050, August 14, 2002). This industry characterization was developed in part under contract with ICF Consulting[1] as well as independent analyses conducted by EPA through interaction with the industry and other sources.[2,3,4]

2.1.1 The Supply Side

This section describes the types of recreational boats that may contain CI marine engines, the inputs used to manufacture both boats and engines, and the costs associated with boat and engine production.

2.1.1.1 Product Types

Diesel engines are primarily available in inboard marine configurations and are most commonly found in inboard cruisers and inboard runabouts. The National Marine Manufacturers Association estimates that 18 percent of all inboard boats are equipped with diesel engines, with the dominant application being cruisers.[5] Diesel engines are also available in sterndrive configurations on a limited basis, and in the past, a small number of outboard boats contained diesel engines as well (currently there are no outboard diesel engines being manufactured). Descriptions of these boat types, taken from the Economic Impact Analysis of the Proposed Boat Manufacturing NESHAP, are provided here[6]:

- **Inboard runabouts** are mid-sized boats powered by an attached engine located inside the hull at the middle or rear of the boat, with a prop shaft running through the bottom of the boat. Most inboard runabouts are tournament ski boats.

- **Inboard cruisers** are large boats with cabins. Almost all cruisers are equipped with two inboard engines.
- **Sterndrives** are mid-sized boats powered by an attached inboard engine combined with a drive unit that is located on the transom at the stern (rear) of the boat. Sterndrives are also known as inboard/outboards or I/Os.
- **Outboards** are small to medium-sized boats powered by a self-contained detachable engine and propulsion system, which is attached to the transom. This category of boats includes most runabouts, bass boats, utility boats, offshore fishing boats, and pontoons.

Larger boats are powered exclusively by diesel inboard engines. These boats are generally 40 feet or greater in length. Recreational boats in ports with access to the ocean (e.g. Seattle) can be 80 to 100 feet or longer. The larger boats typically require twin inboard diesel engines with 2,000 total horsepower or more. Recreational diesel marine engines are generally produced by domestic companies that have been long-standing players in the marine diesel engine market. The three companies that tend to dominate the market are Caterpillar, Cummins, and Detroit Diesel (see Section 2.1.3.2 for details about these companies). Nearly 75 percent of diesel engines sales for recreational vessels in 2000 can be attributed to these three companies.

Sterndrive boats equipped with diesel engines account for less than 1 to 2 percent of the market. A minority of mid-sized boat owners insist on diesel powered sterndrive engines for their boats.   Diesel marine sterndrive systems generally power the same types of boats as their gasoline counterparts, which tend to be 15 to 30 feet in length. Customers that choose a diesel sterndrive marine engine are generally seeking three main advantages over gasoline sterndrive marine engines. First, diesel fumes are much less ignitable and explosive that gasoline fumes. Second, diesel powered craft have a greater range than gasoline powered craft with similar fuel capacity. Lastly, diesel engines tend to be more reliable and tend to run more hours between major overhauls than gasoline engines. This last point is particularly important to boat owners who operate their boats higher than the average.

One major disadvantage of diesel sterndrive engines is their cost relative to comparably powered gasoline sterndrive engines. For example, a 40 foot twin cabin cruiser with twin gasoline sterndrive engines costs $238,000. For twin diesel sterndrive engines, the price increases by approximately $50,000. The fact that the diesel engine is more expensive, coupled with the fact that diesel fuel is often less available than gasoline in the U.S., has resulted in limited domestic demand for recreational diesel sterndrive marine engines.

2.1.1.2 Primary Inputs

The primary inputs used to produce marine engines and recreational boats, can be divided into four major categories: capital, labor, energy, and materials. Capital refers to the type of equipment used in production where the type of capital depends upon the good being produced. The same is true for labor, as different skills are required for the production of boats relative to engines. Energy refers to the electricity, natural gas, or other power sources used to operate production equipment and plants at which boats and engines are manufactured. Material inputs are what differ the most across the production of these end products. The remainder of this section focuses on the different materials used to produce CI marine engines and recreational boats.

Some of the main materials used to produce CI marine engines include fluid power pumps, motors, and transmissions; fluid power cylinders, filters, valves, hoses, and their assemblies; metal bolts, nuts, screws, washers, and tanks; iron, steel, and nonmetal forgings and castings; steel bars, plates, piston rings, and other steel shapes and forms; gears, gaskets, and fabricated plastic products; engine electrical equipment such as spark plugs, generators, and starters; and rubber and plastic hosing and belting. All of these inputs are used in conjunction with energy, capital, and skilled labor to manufacture engines.

Main inputs used in the production of recreational boats include marine engines, plastic and aluminum fuel tanks, and rubber fuel hoses. However, these are but a few of the materials used in boat manufacturing. Others include marine metal hardware, such as propellers, castings, screws, washers, and rivets; metal forgings, castings, and other steel forms; aluminum and aluminum-base alloy sheet, plate, foil, rod, bars, and pipes; fiberglass, lumber, plywood, canvas products, and carpeting; plastic rods, tubes, and shapes; and paints, varnishes and lacquers.

2.1.1.3 Costs of Production

The historical production costs of marine engines and recreational boats are divided into the primary input categories of labor, materials, and capital expenditures. Table 2.1-1 presents the value of shipments (VOS), production costs, and production costs as a share of the VOS for the other engine equipment manufacturing industry (which includes marine engine manufacturing). Table 2.1-2 shows the same figures for the boat manufacturing industry. The other engine equipment manufacturing industry is identified by Standard Industrial Classification (SIC) code 3519 and the North American Industrial Classification System (NAICS) code 333618. The SIC code and the NAICS code for the boat building industry are 3732 and 336612.

For both engine manufacturing and boat building, the average share of the cost of materials and total capital expenditures is similar. The cost of materials represents an average of 57 to 58 percent of the VOS for both industries and average share of capital expenditures for both industries is approximately 2 to 3 percent. Another trend evident for both industries is that the cost shares of materials and payroll tended to be higher in the earlier part of the 1990s than in the late 1990s. Payroll, which includes the costs associated with employee wages and benefits, differs slightly across the industries. For the boat manufacturing industry, payroll represents an average of 20 percent of VOS while for engine manufacturing, it is equal to an average share of 14 percent of its shipment value.

Also notable in these tables is that the average VOS for the engine manufacturing industry, over $16 billion, is about three times the average VOS for the boat manufacturing industry. It is important to keep in mind that the data in Table 2.1-1 include other engine equipment manufacturing and does not represent marine engine manufacturing exclusively. Likewise, the figures in Table 2.1-2 for boat manufacturing include vessels that are not powered by CI engines, such as outboards, jet skis, personal water craft, and boats that are not motorized, such as canoes and kayaks.

Table 2.1-1
Value of Shipments and Production Costs for the SIC and NAICS Codes that Include Recreational Boat Engine Manufacturers*, 1992 - 1999 [7,8,9,10,11,12,13]

Year	Industry Code	Value of Shipments ($\$10^6$)	Payroll ($\$10^6$)	Payroll % of VOS	Cost of Materials ($\$10^6$)	Cost of Materials % of VOS	Total Capital Expenditures ($\$10^6$)	Total Capital Expenditures % of VOS
1992	SIC 3519	$11,827	$2,072	18%	$6,996	59%	$461	4%
1993	SIC 3519	$12,600	$1,900	15%	$7,545	60%	$371	3%
1994	SIC 3519	$15,308	$2,162	14%	$8,977	59%	$406	3%
1995	SIC 3519	$16,642	$2,238	13%	$9,940	60%	$499	3%
1996	SIC 3519	$17,286	$2,237	13%	$9,905	57%	$528	3%
1997	NAICS 333618	$19,011	$2,374	12%	$10,539	55%	$631	3%
1998	NAICS 333618	$20,312	$2,471	12%	$11,963	59%	$682	3%
1999	NAICS 333618	$22,389	$2,652	12%	$12,474	56%	$786	4%
	Average	$16,922	$2,263	14%	$9,792	58%	$545	3%

* Value of Shipments, Payroll, Cost of Materials, and Total Capital Expenditures are in nominal U.S. dollars

Table 2.1-2
Value of Shipments, and Production Costs for the SIC and NAICS Codes that Include Recreational Boat Manufacturers*, 1992 - 1999 [14,15,16,17,18,19,20]

Year	Industry Code	Value of Shipments ($\$10^6$)	Payroll ($\$10^6$)	Payroll % of VOS	Cost of Materials ($\$10^6$)	Cost of Materials % of VOS	Total Capital Expenditures ($\$10^6$)	Total Capital Expenditures % of VOS
1992	SIC 3732	$4,599	$1,006	22%	$2,609	57%	$63	1%
1993	SIC 3732	$4,975	$1,033	21%	$2,919	59%	$83	2%
1994	SIC 3732	$5,334	$1,081	20%	$3,075	58%	$90	2%
1995	SIC 3732	$5,597	$1,105	20%	$3,218	57%	$89	2%
1996	SIC 3732	$5,823	$1,177	20%	$3,396	58%	$109	2%
1997	NAICS 336612	$5,607	$1,030	18%	$3,237	58%	$122	2%
1998	NAICS 336612	$5,939	$1,114	19%	$3,202	54%	$263	4%
1999	NAICS 336612	$7,463	$1,361	18%	$4,099	55%	$231	3%
	Average	$5,667	$1,113	20%	$3,219	57%	$131	2%

* Value of Shipments, Payroll, Cost of Materials, and Total Capital Expenditures are in nominal U.S. dollars

Looking specifically at the engine manufacturing industry, we see that the share of payroll steadily declined over the 1992 - 1999 time period. In 1992, payroll represented 18 percent of the VOS but by 1995, it was down to 13 percent. Labor costs fell to 12 percent of the VOS in 1997 and remained at this lower share value through 1999. A declining trend is also evident for the share of payroll for the boat manufacturing industry, however it was more recently that the share of labor costs fell. In 1992, labor costs were equal to 22 percent of the boat manufacturing industry's VOS. It dropped to 20 percent from 1994 to 1996 and most recently was equal to 18 to 19 percent in the late 1990s.

2.1.1.4 Recreational Boat Production Practices

Based on information supplied by a variety of recreational boat builders, the following discussion provides a description of the general production practices used in this sector of the marine industry.

Engines are usually purchased from factory authorized distribution centers. The boat builder provides the specifications to the distributor who helps match an engine for a particular application. It is the boat builders responsibility to fit the engine into their vessel design. The reason for this is that sales directly to boat builders are a very small part of engine manufacturers' total engine sales. These engines are not generally interchangeable from one design to the next. Each recreational boat builder has their own designs. In general, a boat builder will design one or two molds that are intended to last 5-8 years. Very few changes are tolerated in the molds because of the costs of building and retooling these molds.

Recreational vessels are designed for speed and therefore typically operate in a planing mode. To enable the vessel to be pushed onto the surface of the water where it will subsequently operate, recreational vessels are constructed of lighter materials and use engines with high power density (power/weight). The tradeoff on the engine side is less durability, and these engines are typically warranted for fewer hours of operation. Fortunately, this limitation typically corresponds with actual recreational vessel use. With regard to design, these vessels are more likely to be serially produced. They are generally made out of light-weight fiberglass. This material, however, minimizes the ability to incorporate purchaser preferences, not only because many features are designed into the fiberglass molds, but also because these vessels are very sensitive to any changes in their vertical or horizontal centers of gravity. Consequently, optional features are generally confined to details in the living quarters, and engine choice is very limited or is not offered at all.

Based on information supplied by a variety of recreational boat builders, fuel tanks for recreational boats are usually purchased from fuel tank manufacturers. However, some boat builders construct their own fuel tanks. The boat builder provides the specifications to the fuel tank manufacturer who helps match the fuel tank for a particular application. It is the boat builder's responsibility to install the fuel tank and connections into their vessel design. For vessels designed to be used with small outboard engines, the boat builder may not install a fuel tank; therefore, the end user would use a portable fuel tank with a connection to the engine.

2.1.2 The Demand Side

The information provided in this section addresses the various options consumers have available regarding recreational marine vessels and the engines used to power them. Some of the engine-powered recreational boats available to consumers include inboards, sterndrives, outboards, personal water craft, and jet boats.

2.1.2.1 Uses and Consumers

Recreational boats are used for a number of water-related pastimes including fishing, waterskiing, cruising, vacationing, relaxing on the water, sunning, and a host of other activities. Runabouts are commonly used for waterskiing, tubing, and wakeboarding. Larger cruisers and yachts can be used for extended trips because they may be equipped with cabins for cooking and sleeping. Fishing boats can vary in size depending on whether they are used for offshore sport fishing or local lake fishing. Other boats, such as personal water craft, sailboats, canoes, and rowboats can be used for cruising along the water.

According to the National Marine Manufacturers Association (NMMA), there are currently close to 70 million people participating in recreational boating. In the late 1990s, this figure was closer to 80 million, but the recent economic downturn has led consumers to engage in fewer leisure activities. From Table 2.1-3, we can see that outboard boats are the most common boat type, followed further behind by inboard and sterndrive boats. The number of inboards and sterndrives owned in the U.S. are roughly equivalent over the 1997 to 2001 time period.

Table 2.1-3
Recreational Boating Population Estimates (10^3)*, 1997 - 2001 [21,22]

	1997	1998	1999	2000	2001
People participating in recreational boating	78,406	74,847	73,208	72,269	69,486
All boats in use	16,230	16,824	16,790	16,991	16,999
Outboard boats owned	8,125	8,300	8,211	8,288	8,342
Inboard boats owned	1,587	1,609	1,635	1,660	1,678
Sterndrive boats owned	1,582	1,673	1,665	1,709	1,743
Personal water craft	1,000	1,100	1,096	1,078	1,631

* These in-use figures are based on the actual state and Coast Guard registrations. Population estimates are rounded to the nearest thousandths.

The type of boat purchased by a consumer and the type of engine it is equipped with are affected by the recreational activity the consumer plans to engage in, the size of the boat being purchased, and other consumer preferences. For example, if a larger inboard cruiser is selected for purchase, the consumer will likely opt for a diesel engine. Diesel engines are, in general, more expensive, but have a longer life span than gasoline engines. In addition, diesel engines are available at much higher power ratings. However, if the consumer prefers a smaller fishing boat with an outboard engine configuration, it will be equipped with a gasoline engine.

Generally speaking, recreational boats are considered final goods while the engines that power them are intermediate goods. As discussed in Section 2.1.1.4, boat builders purchase engines from distribution centers and then use these engines as inputs to the production of boats. Boat builders may provide their own engine designs to engine manufacturers so that the engines will properly fit into the boat builders' specific models.

2.1.2.2 Substitution Possibilities

Consumers can substitute across different boat types but may be limited by the water-related activities they want to engage in. Runabouts and cruisers are available in different engine configurations and different engine types. Consumers will first evaluate the purpose for which they'd like to buy a boat and will then consider the various types of boats that will suit their preferences. If consumers choose to purchase either sterndrive or inboard boats, they have both diesel and gasoline engines available to them. Outboards, on the other hand, are only available with gasoline engines.

Consumers may be interested in engaging in water-related activities, but may instead consider purchasing non-motorized boats. For example, consumers who are like to float out on the water or engage in lake fishing may choose to purchase a sailboat, row boat, or canoe. These non-motorized boating options do not allow the consumer to participate in the same set of water-related activities as would the purchase of a motorized boat, but they may be considered substitutes for less intensive water-related past times.

2.1.3 Industry Organization

It is important to gain an understanding of how the recreational marine vessel and CI marine engine industries may be affected by the emissions control program. One way to determine how increased costs might affect the market is to examine the organization of each industry. This section provides data to measure the competitive nature of the boat building and marine engine industries and lists the manufacturers of recreational boats, marine engines, and marine fuel tanks.

2.1.3.1 Market Structure

Market structure is of interest because it determines the behavior of producers and consumers in the industry. In perfectly competitive industries, no producer or consumer is able to influence the price of the product sold. In addition, producers are unable to affect the price of inputs purchased for use in production. This condition is most likely to hold if the industry has a large number of buyers and sellers, the products sold and inputs used are homogeneous, and entry and exit of firms is unrestricted. Entry and exit of firms are unrestricted for most industries, except in cases where the government regulates who is able to produce output, where one firm holds a patent on a product, where one firm owns the entire stock of a critical input, or where a single firm is able to supply the entire market. In industries that are not perfectly competitive, producer and/or consumer behavior can have an effect on price.

Concentration ratios (CRs) and Herfindahl-Hirschman indices (HHI) can provide some insight into the competitiveness of an industry. The U.S. Department of Commerce reports these ratios and indices for the six digit NAICS code level for the year 1997, the most recent year available. Tables 2.1-4 and 2.1-5 provide the four- and eight-firm concentration ratios (CR4 and CR8, respectively) and the Herfindahl-Hirschman indices for the other engine equipment manufacturing and boat building industries (the other engine equipment manufacturing industry includes manufacturers of marine engines). These industries are represented by NAICS codes 333618 and 336612, respectively. Concentration ratios are provided in percentage terms while HHI are based on a scale formulated by the Department of Justice.

Table 2.1-4
Measures of Market Concentration for the NAICS Code that Includes Recreational Boat Engine Manufacturers, 1997 [23]

Description	CR4	CR8	HHI	VOS ($\$10^6$)	Number of Companies
NAICS 333618	55.8	76.0	1019.1	$19,011.09	245

Table 2.1-5
Measures of Market Concentration for the NAICS Code that Includes Recreational Boat Manufacturers, 1997 [24]

Description	CR4	CR8	HHI	VOS ($\$10^6$)	Number of Companies
NAICS 336612	41.4	48.9	644.5	$5,607.30	984

The criteria for evaluating the HHI are based on the 1992 Department of Justice Horizontal Merger Guidelines. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive). In general, firms in less concentrated industries have more ability to influence market prices. Based on these criteria, the marine vessel industry can be modeled as perfectly competitive for the purposes of the economic impact analysis. The other engine equipment manufacturing industry is slightly more concentrated, with higher CRs and an HHI value just over 1,000. However, it is reasonable to assume that the marine engine manufacturing industry is perfectly competitive for the economic analysis.

2.1.3.2 CI Marine Engine and Recreational Boat Manufacturers

We have determined that there are at least 16 companies that manufacture CI marine engines for recreational vessels. Nearly 75 percent of diesel engines sales for recreational vessels in 2000 can be attributed to three large companies. Six of the identified companies are considered small businesses as defined by the Small Business Administration SBA) size standard for NAICS code 333618 (less than 1000 employees). Based on sales estimates for 2000, these six companies represent less than 5 percent of recreational marine diesel engine sales. Table 2.1-6 provides a list of the diesel engine manufacturers identified to date by EPA.

Table 2.1-6
Annual Sales for Recreational Diesel Marine Engine Manufacturers Identified by EPA, 2000/2001 [25,26,27]

Companies with greater than 1,000 employees	Annual Sales[a] ($10^6)	Companies with less than 1,000 employees	Annual Sales[a] ($10^6)
Caterpillar, Inc. (Engines Div.)[b]	**$2,176.0**	Alaska Diesel Electric/Lugger	$9.2
Cummins Engine Company, Inc.	**$6,600.0**	American Diesel Corporation	$5.0
Detroit Diesel Engines	**$2,358.7**	Daytona Marine	$2.9
Isotta Fraschini	NA[c]	Marine Power, Inc.	$7.0
Deere & Company	$13,137.0	Peninsular Diesel Engines, Inc.	NA[c]
Marine Corporation of America	NA[c]	Westerbeke Corporation	$29.1
Mercruiser	$68.6		
MTU Aero Engine Components	$7.9		
Volvo Penta	$275.0		
Yanmar Diesel America Corporation	$18.9		

[a] Annual sales of listed companies include revenues received from the sale of all products sold by these companies, not just revenues received from the sales of diesel marine engines.
[b] Companies in **bold** dominate the diesel engine market for recreational vehicles.
[c] NA means Not Available.

Less precise information is available about recreational boat builders than is available about engine manufacturers. Several sources were used, including trade associations, business directories, and Internet sites when identifying entities that build and/or sell recreational boats. We have also worked with an independent contractor to assist in the characterization of this segment of the industry. Finally, we have also obtained a list of nearly 1,700 boat builders known to the U.S. Coast Guard to produce boats using recreational gasoline and diesel engines. At least 1,200 of these companies install gasoline-fueled engines and would therefore be subject to the proposed evaporative emission standards. More that 90 percent of the companies identified to date would be considered small businesses as defined by SBA size standards for NAICS code 336612 (less than 500 employees). Table 2.1-7 provides a sample of recreational boat manufacturers known to EPA.

Table 2.1-7
Annual Sales and Employment for a Sample of Recreational Boat Manufacturers Identified by EPA, 2000/2001 [28,29,30]

Company	Annual Sales[a] ($$10^6$)	Employment
Bayliner Marine Corporation	$450.0	2,500
Beneteau USA Limited	$1.7	10
Boston Whaler, Inc.	$6.0	600
Brunswick Marine Group	$483.0	2,900
Carver Boat Corporation	$149.8	1,300
Catalina Yachts	$35.0	250
Correct Craft, Inc.	$35.0	250
Crestliner, Inc.	$50.0	350
Fiberglass Unlimited	$1.0	16
Fountain Powerboats, Inc.	$57.5	390
Four Winns, Inc. LLC	$46.6	500
Genmar Industries	$869.0	6,500
Glastron Boats	$58.0	650
Godfrey Marine	$51.4	550
Grady-White Boats, Inc.	$55.0	500
Hood Yacht Systems	NA[b]	NA[b]
Lowe Boats	$43.8	380
Lund Boat Company	$60.4	525
Magnum Marine Corporation	$6.9	60
Mariah Boats, Inc.	$31.7	275
MasterCraft Boat Company	$87.0	500
Morgan Marine	$37.1	400
Ocean Yachts, Inc.	$14.6	150
Old Town Canoe Company	$11.5	100
Palmer Johnson, Inc.	$23.0	200
Porta-Bote International	$3.6	32
Regal Marine Industries, Inc.	$85.0	700
S2 Yachts, Inc.	$78.0	600
Sabre Corporation	$18.4	160
Sea Ark Boats, Inc.	$6.0	100
Seaswirl Boats, Inc.	$28.8	250
Skeeter Boats, Inc.	$45.0	200
Smoker-Craft Boats, Inc.	$52.0	400
Sport-Craft Boats, Inc.	$23.0	200
Sunbird Boat Company, Inc.	$28.8	250
Tracker Marine, LLP	$57.0	2,400

[a] Annual sales of listed companies include revenues received from the sale of all products sold by these companies, not just revenues received from the sales of recreational boats.
[b] NA means Not Available.

2.1.4 Markets

This section examines select historical market statistics for inboard and sterndrive boats and engines. It presents domestic quantities, values, and unit prices for both boat types as well as shipment data for inboard and sterndrive engines. Also presented are quantities and values of exports and imports of both inboard and sterndrive boats and engines. The section concludes with the current trends of the marine industry. EPA focuses on these two boat configurations because they are available with diesel engines.

2.1.4.1 Quantity and Price Data

Quantities of shipments produced domestically, real values of shipments, and unit price data are presented in Tables 2.1-8 through 2.1-10 for inboard runabouts, inboard cruisers, and sterndrive boats equipped with SI and CI engines (disaggregated data were not available by engine type). Real unit price data are calculated by simply dividing real value of shipments by the quantity of shipments produced. Also provided are domestic shipment data for inboard and sterndrive engines in Table 2.1-11 (price data were not available). While a fraction of inboard boats are equipped with diesel engines (approximately 18 percent), recall that only 1 to 2 percent of sterndrive boats contain diesel engines and that sterndrives with diesel engines are more expensive than those operating with SI engines. Also note that virtually all diesel engines in inboard boats are placed in cruisers. Only 1 to 2 percent of inboard runabouts contain CI engines. Because these three boat categories may contain diesel engines, their market data are discussed here.

An overall examination of the data for all three boat types shows that the quantity of shipments, real value of shipments, and real unit values all increased over the 1980 to 2000 time period. Comparing across these boat types shows that the average annual growth rates are highest for quantities and shipment values for inboard runabouts (9.5 percent for the quantity of shipments and close to 12 percent for the real value of shipments). The average growth rates for these same variables are lowest for sterndrive boats (the quantity of shipments grew at an average annual rate of under 4 percent and the average annual growth rate for the value of shipments was 5 percent). Also notable is that the unit price of inboard runabouts increased, on average, at a lower rate than for inboard cruisers and sterndrives. Though the average annual growth rates are positive across the variables presented, there is definite evidence of dips in the quantity of shipments and real value of shipments for inboard cruisers, and in all three variables for sterndrive boats. These trends are not existent for inboard runabouts. Before examining the historical data presented for inboard cruisers and sterndrives, a closer examination at inboard runabouts is warranted.

Table 2.1-8
Recreational Inboard Runabout Boats - Domestic Quantity of Shipments, Value of Shipments, and Unit Values, 1980 - 2000 (1996$) [31,32]

Year	Quantity of Shipments (units)	Real Value of Shipments ($$10^3$)	Real Unit Value ($)
1980	2,900	$52,226	$18,009
1981	2,950	$55,860	$18,935
1982	3,200	$63,030	$19,697
1983	3,900	$71,217	$18,261
1984	4,500	$84,727	$18,828
1985	4,500	$92,238	$20,497
1986	5,300	$113,964	$21,503
1987	6,600	$137,669	$20,859
1988	7,400	$163,263	$22,063
1989	9,100	$215,846	$23,719
1990	7,500	$152,414	$20,322
1991	6,200	$129,380	$20,868
1992	6,400	$126,358	$19,743
1993	6,800	$141,809	$20,854
1994	7,200	$148,725	$20,656
1995	6,900	$150,673	$21,837
1996	6,000	$126,234	$21,039
1997	6,100	$133,733	$21,923
1998	6,900	$155,707	$22,566
1999	12,100	$293,742	$24,276
2000	13,600	$342,465	$25,181
Avg. Annual Growth Rate	9.5%	11.9%	1.9%

Of the three boat types presented here, domestic shipments and the real value of domestic shipments grew at a higher annual rate, on average, for inboard runabouts. In 1980, just under 3,000 inboard runabouts were being manufactured and distributed in the U.S. The real value of these boats (in 1996 dollars) was over $52 million, with the average inboard runabout equal to a real value of $18,000. By 1990, both the quantity of shipments and the real value of shipments more than doubled. Unit prices increased, but only by 12 percent. In 2000, quantity of shipments, shipment values, and unit values hit their peak. U.S. shipments of inboard runabouts were equal to 13,600, real value of shipments equaled over $342 million, and the real value was just over $25,000.

Table 2.1-9
Recreational Inboard Cruiser Boats - Domestic Quantity of Shipments, Value of Shipments, and Unit Values, 1980 - 2000 (1996$) [33,34]

Year	Quantity of Shipments (units)	Real Value of Shipments ($$10^3$)	Real Unit Value ($)
1980	5,300	$802,253	$151,368
1981	5,450	$861,890	$158,145
1982	5,125	$854,167	$166,667
1983	7,485	$1,060,700	$141,710
1984	10,780	$1,604,094	$148,803
1985	12,200	$1,811,865	$148,514
1986	12,700	$1,894,840	$149,200
1987	13,100	$2,135,718	$163,032
1988	13,500	$2,355,750	$174,500
1989	12,300	$2,299,952	$186,988
1990	7,500	$1,589,672	$211,956
1991	3,600	$742,680	$206,300
1992	3,550	$675,032	$190,150
1993	3,375	$696,830	$206,468
1994	4,200	$927,793	$220,903
1995	5,460	$1,193,367	$218,565
1996	5,350	$1,215,268	$227,153
1997	6,300	$1,636,375	$259,742
1998	6,600	$1,631,720	$247,230
1999	7,000	$1,713,733	$244,819
2000	8,000	$2,123,768	$265,471
Avg. Annual Growth Rate	5.0%	7.9%	3.1%

Inboard cruisers are larger boats and hence have higher value of shipments and average unit value measures. An examination of Table 2.1-9 shows that this market has grown over the 1980 to 2000 time period. Evidence of growth in this market can be seen by examining the average annual growth rates. The real average price of an inboard cruiser was equal to slightly more than $151,000 in 1980, but by the year 2000, prices reached a peak of $265,471 (a net price increase of 75 percent). Real shipment values also showed a large increase starting at $802 million in 1980 and rising to over $2.1 billion in 2000. The reason for the large price increase is evident because the rise in the quantity of shipments from 1980 to 2000 was not as dramatic as the rise in the real value of shipments. The net increase in the quantity of shipments for the 1980 to 2000 time period was 50 percent.

During the mid to late 1980s, the quantity and real shipment values of inboard cruisers steadily increased to reach their peak. In 1983, 7,485 inboard cruisers were manufactured with a total real value of $1.6 billion. By 1988, shipments rose to 13,500 and the real value of shipments exceeded $2.35 billion. The average value of this boat type in this same year was $174,500. This surge in the market for inboard cruisers was followed by a large decline in the quantities and values of shipments. By 1993, the domestic quantity of inboard cruisers fell to its lowest level at 3,375 and real value of shipments was close to its lowest level at just under $700 million.

Table 2.1-10
Recreational Sterndrive Boats - Domestic Quantity of Shipments, Value of Shipments, and Unit Values, 1980 - 2000 (1996$) [35,36]

Year	Quantity of Shipments (units)	Real Value of Shipments ($$10^3$)	Real Unit Value ($)
1980	56,000	$1,080,702	$19,298
1981	51,000	$1,052,492	$20,637
1982	55,000	$1,039,167	$18,894
1983	79,000	$1,412,841	$17,884
1984	108,000	$2,031,008	$18,806
1985	115,000	$2,247,784	$19,546
1986	120,000	$2,481,280	$20,677
1987	144,000	$3,141,231	$21,814
1988	148,000	$3,230,840	$21,830
1989	133,000	$2,836,265	$21,325
1990	97,000	$2,062,421	$21,262
1991	73,000	$1,436,559	$20,553
1992	75,000	$1,347,147	$19,251
1993	75,000	$1,322,872	$17,580
1994	90,000	$1,738,313	$17,271
1995	93,000	$1,827,867	$18,920
1996	64,500	$1,925,248	$19,138
1997	92,000	$2,027,969	$29,264
1998	91,000	$2,046,755	$21,829
1999	79,600	$1,956,644	$22,063
2000	78,400	$2,106,395	$24,122
Avg. Annual Growth Rate	3.7%	5.0%	2.0%

The annual domestic quantities of sterndrive boat shipments far exceed the quantities of inboard runabouts and inboard cruisers combined. They are mostly equipped with gasoline engines and are in a similar price range as inboard runabouts. A closer examination of Table 2.1-10 shows that this market peaked and dipped during the same years as the inboard cruiser market. This general expansion of the market for recreational boats in the late 80s was due to higher economic growth for the U.S. In 1988, shipments of sterndrives were equal to 148,000 (an 87 percent increase over the year 1983 quantity) and shipment values were equal to over $3.2 billion (a 128 percent increase in the real shipment value in 1983). Also notable is that though unit values of sterndrives are far less than those for inboard cruisers, the real value of shipments are very close for these boat types (approximately $2.1 billion in the year 2000). The value of the market for inboard runabouts is far smaller at a value of $342 million in 2000.

Table 2.1-11 below provides the quantity of shipments of inboard and sterndrive engines combined. These data also combine gasoline and diesel engines. What is clear from this table is that the shipment quantities tend to reflect the peaks and dips seen in the data for sterndrives and inboard cruisers. Domestic engine shipments rose to their highest value in 1988 at a total of 211,900. They then fell over the remainder of the 1980s and early 1990s to quantities in the low 90 thousands. In the mid 1990s there was a slight rise in engine shipments to a total of 120,000 but in the year 2000, the quantity fell to just over 105,000.

Table 2.1-11
U.S. Shipments of Inboard and Sterndrive Engines, 1980 - 2001 [37]

Year	Quantity of Shipments	Year	Quantity of Shipments
1980	87,750	1991	92,400
1981	81,500	1992	94,600
1982	85,650	1993	94,700
1983	104,125	1994	114,000
1984	148,000	1995	120,000
1985	155,000	1996	120,000
1986	161,900	1997	116,100
1987	210,800	1998	104,500
1988	211,900	1999	108,500
1989	190,700	2000	110,400
1990	134,100	2001	105,800

2.1.4.2 Foreign Trade

Tables 2.1-12 and 2.1-13 present trade data for inboard and sterndrive boats. Over the 1992 to 2000 time frame, import values of these boat types grew. A large increase in the value of inboard cruiser imports was evident from 1999 to 2000. Though they initially are larger, export values for these boat types do not show the same rising trend. For both boat types, export values dipped in the early 1990s and then steadily rose through the remainder of the decade. Inboard export value never recovered to its 1992 level, but sterndrive exports did. In fact, the 2000 value of sterndrive exports exceeded its value in 1992.

Further comparisons can be made between exports and imports of each boat type. As the data in these tables show, inboard import values exceeded their export values during the latter half of the 1990s. This was not always the case, as prior to 1996, export values were greater. In 1992, the value of inboard imports was only equal to 16 percent of the value of exports but by 1995, they caught up to exports and equaled 92 percent of inboard export values. In 2000, inboard exports were equal to a fraction of their imports (37 percent).

Table 2.1-12
Import Values[a] (10^3) of Inboard and Sterndrive Boats, 1992 - 2000 [38,39]

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Inboard Runabouts	8,957	16,781	21,069	56,199	135,800	221,497	301,226	348,107	303,910
Inboard Cruisers[b]	32,859	87,997	113,858	143,620	142,007	90,184	113,173	151,170	220,214
Inboards Total	41,816	104,778	134,927	199,819	277,807	311,681	414,399	499,277	524,124
Sterndrive Runabouts	10,900	7,965	9,479	15,224	12,090	11,637	22,494	27,894	30,139
Sterndrive Cruisers[c]	10,976	10,302	18,042	14,779	15,955	15,414	42,599	53,653	70,725
Sterndrives Total	21,876	18,267	27,521	30,003	28,045	27,051	65,093	81,547	100,864

[a] Import values are in nominal U.S. dollars.
[b] Data for inboard cruisers are for those over 24 feet in length.
[c] Data for sterndrive cruisers are for those over 20 feet in length.

Table 2.1-13
U.S. Export Values* (10^3) of Inboard and Sterndrive Boats, 1992 - 2000 [40,41]

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Inboards	261,474	184,673	163,284	217,443	189,825	222,976	213,111	197,260	198,257
Sterndrives	189,463	127,382	135,229	186,230	191,327	199,364	198,675	236,326	198,349

* Export values are in nominal U.S. dollars.

In the case of sterndrives, import values remained below the value of sterndrive exports over the 1992 to 2000 time period. In 1992, imports were equal to approximately 12 percent of export values. The value of imports did approach exports through the decade and by 2000, they were equal to about 50 percent of the value of exports. What is notable is a large jump in the value of sterndrive import values between the years 1997 and 1998. Imports rose from approximately $27 million to over $65 million in the span of this year. Sterndrive export values generally increased through the year 1999 when they hit their peak at $236 million, however in the year 2000, they fell to just below $200 million. Still, export values for sterndrives were twice the value of their imports in this year.

Tables 2.1-14 and 2.1-15 present foreign trade data for inboard diesel and sterndrive engines. Import data for inboard diesel engines were disaggregated by varying ranges of horsepower (ranging from less than 150 to over 1000 horsepower) while inboard export data are only available for diesel engines below 200 horsepower. Sterndrive engine data were not available in disaggregated form. An examination of Table 2.1-14 shows that the total import value of inboard diesel engines declined and rose over the 1990s. In the early part of the 1990s, imports of inboard diesel engines steadily declined in value, but then rose dramatically in 1995. This anomalous year was followed by a decline in import value which remained relatively constant until it again rose in 2000. For sterndrive engines, import values grew dramatically in the beginning of the 1990s as well. They then dipped during the mid 1990s only to rise again at the end of the decade to its highest value.

Though Table 2.1-14 only provides inboard import data for diesels, it is clear that the value of these engine imports exceed the value of sterndrive engine imports. We can infer that fewer sterndrive engines were imported relative to inboard engines. Note however, that inboard engines may also be used for boats with sterndrive engine configurations, which may partially explain why the import values for inboard engines are much higher.

Export data for the various types of inboard diesel engines were not available, therefore we are unable to make direct comparisons across the total import and export values of these engines. Some comparison can be made between the import values of inboard diesel engines below or equal to 150 horsepower and export values of inboard diesel engines under 200 horsepower since these generally refer to the same set of engines. A comparison of the these values shows roughly equal values of imports and exports of this engine type in the 1990s. Overall, export values are slightly higher. Sterndrive engine import and export values can be directly compared as these measures represent all foreign trade of this engine type to and from the U.S. From these tables, we can see that export values of sterndrive engines far exceeded import values in the beginning of the 1990s. However the value of imports for this engine type approached its export value by 1995. For the latter half of the 1990s, export values remained higher but the difference between export and import values remained smaller.

Table 2.1-14
U.S. Import Values* ($\$10^3$) of Inboard Diesel Engines and Sterndrive Engines, 1992 - 2000 [42,43]

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Inboard Diesels									
$\leq$ 150HP	17,270	14,230	10,104	8,765	10,050	6,933	9,244	13,992	15,084
150-199HP	4,901	4,983	5,384	5,539	5,701	7,915	6,528	6,114	6,916
200-312HP	9,035	9,805	9,153	10,721	7,102	8,851	10,355	13,032	8,756
313-499HP	4,910	4,288	7,625	7,796	7,634	9,624	15,609	21,332	38,506
500-999HP	5,365	5,994	8,418	14,257	15,174	13,494	9,808	10,836	12,725
$\geq$ 1000HP	72,606	40,611	18,577	24,680	39,965	31,486	33,777	29,002	43,698
Inboard Total	114,087	79,911	59,261	293,878	85,626	78,303	85,321	94,308	125,685
Sterndrive Engines									
Total	3,221	5,947	19,045	25,401	21,586	15,457	17,525	25,434	43,489

* Import values are in nominal U.S. dollars.

Table 2.1-15
U.S. Export Values* ($\$10^3$) of Diesel Inboard Engines Under 200 HP and Sterndrive Engines, 1992 - 2000 [44,45]

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Inboard Engines	11,174	11,332	8,962	15,263	13,976	20,201	18,665	19,123	23,543
Sterndrive Engines	25,186	24,164	25,024	28,386	26,980	23,734	17,089	24,430	30,427

* Export values are in nominal U.S. dollars.

2.2 Large SI Engines and Industrial Equipment

This section gives a general characterization of the Large SI industry. Large SI engines are nonroad spark-ignition engines that have rated power higher than 25 horsepower (19 kW) and that are not recreational engines or marine propulsion engines. They are typically derivatives of automotive engines, but use less advanced technology and operate on LPG and CNG as well as gasoline. Large SI engines are used in a wide variety of commercial uses. Because it is not practical to present detailed information on all of these applications in this section, we focus primarily on forklifts. This is reasonable because they are the dominant application for Large SI engines. Also, as explained in greater detail in Section 9.7 of Chapter 9, the detailed economic impact analysis performed for this sector focuses on forklifts. Other information presented in this section describes some general characteristics of the Large SI sector.

2.2.1 The Supply Side

This section provides a description of the types of industrial equipment that may contain Large SI engines, the major inputs used to manufacture this equipment, and the costs of production.

2.2.1.1 Product Types and Populations

Large SI engines are used in a wide variety of applications, including forklifts, generators, pumps, leaf blowers, sprayers, compressors, other material handling equipment, and agricultural production. Table 6.2.2-1 in Chapter 6 presents our estimates of the 2000 U.S. population of the various Large SI equipment applications. We estimated populations of engine and equipment models using historical sales information adjusted according to survival and scrappage rates.

A 1996 study of the forklift market estimated that there were 491,321 engine-powered forklifts in use in the United States in 1996 (Classes 4, 5, and 6; see below for an explanation of these classes).[46] That study estimated that 80 percent of this population used LPG (commonly referred to as propane because propane is its primary constituent), with the rest running on either gasoline or diesel fuel. If that 20 percent of that population are split evenly between gasoline and diesel fuels, as we estimate, this means that the number of spark-ignition forklifts in 1996 was about 442,000, or that about 90 percent of all forklifts were spark-ignition. As noted in Table 6.2.2.1, we estimate that about 95 percent of those spark-ignition forklifts are run LPG or CNG, with the rest being run on gasoline. The high percentage of propane systems for forklifts can be largely attributed to expenses related to maintaining fuel supplies. LPG cylinders can be readily exchanged with minimal infrastructure cost. Installing and maintaining underground tanks for storing gasoline has always been a significant expense, which has become increasingly costly due to the new requirements for replacing underground tanks.

With regard to non-forklift applications, the split between LPG and gasoline is not as clear. Large SI engines today are typically sold without fuel systems, which makes it difficult to assess the distribution of engine sales by fuel type. Also, engines are often retrofitted for a different fuel after the initial sale, making it still more difficult to estimate the prevalence of the different fuels. Natural gas, a third option, is less common in Large SI engines even though natural gas and LPG fuel systems are very similar. Natural gas supply systems typically offer the advantage of pipeline service, but the cost of installing high-pressure refueling equipment is an obstacle to increased use of natural gas. Table 6.6.2.1 contains our estimates of the use of LPG and CNG for non-forklift applications; the rest are estimated to use gasoline. We estimate 100 percent LPG/CNG use for oil field equipment, gas compressors, and refrigeration/AC. For construction, general industrial, and other nonroad equipment, there may be a mix of central and noncentral fueling; we therefore believe that estimating an even mix of LPG and gasoline for these engines is most appropriate.

We estimate very low or no LPG/CNG use for agricultural and lawncare equipment. Lawn and garden equipment is usually not centrally fueled and therefore operates almost exclusively on gasoline, which is more readily available. Agriculture equipment is predominantly powered by diesel engines. Most agriculture operators have storage tanks for diesel fuel. Those who use spark-ignition engines in addition to, or instead of, the diesel models, would likely invest in gasoline storage tanks as well, resulting in little or no use of LPG or natural gas for those applications. An estimated distribution of fuel types for the individual applications are listed in Table 6.2.2-1.

Large SI engines also vary considerably by size. Most of these engines are smaller than 100 horsepower, with the lower limit of the engine category at 25 horsepower. On an annual sales basis, 34 percent of Large SI engines are less than 50 horsepower, and 80 percent are less than 100 horsepower. Only about 20 percent are larger than 100 horsepower, with the largest about 250 horsepower.

2.2.1.2 Engine Design and Operation

Most engines operate at a wide variety of speeds and loads, such that operation at rated power (full-speed and full-load) is rare. To take into account the effect of operating at idle and partial load conditions, a load factor indicates the degree to which average engine operation is scaled back from full power. For example, at a 0.3 (or 30 percent) load factor, an engine rated at 100 hp would be producing an average of 30 hp over the course of normal operation. For many nonroad applications, this can vary widely (and quickly) between 0 and 100 percent of full power. Table 6.2.2-1 shows the load factors that apply to each nonroad equipment application.

Table 6.2.2-1 also shows annual operating hours that apply to the various applications. These figures represent the operating levels that apply through the median lifetime of equipment.

2.2.1.3 Liquid-Cooled , Automotive-Derived Engines

The majority of Large SI engines are industrial versions of automotive engines and are liquid-cooled. However, in the absence of emission standards there has been only limited transfer of emission-control technology from automotive to industrial engines, and most of these are equipped with only very basic emission control technology if any.

Producing an industrial version of an automotive engine typically involves fitting a common engine block with less expensive systems and components appropriate for nonroad use. Manufacturers remove most of the sophisticated systems in place for the high-performance, low-emission automotive engines to be able to produce the industrial engine at a lower cost. For example, while cars have used electronic fuel systems for many years, almost all industrial Large SI engines still rely on mechanical fuel systems. Chapter 3 describes the baseline and projected engine technologies in greater detail.

2.2.1.4 Air-Cooled Engines

Some manufacturers produce Large SI engines exclusively for industrial use. Most of these are air-cooled. Air-cooled engines with less than one liter total displacement are typically very similar to the engines used in lawn and garden applications. Total sales of air-cooled engines over one liter have been about 9,000 per year, 85 percent of which are rated under 50 hp. While these engines can use the same emission-control technologies as water-cooled engines, they have unique constraints on how well they control emissions. Air-cooling doesn't cool the engine block as uniformly as water-cooling. This uneven heating can lead to cylinder-to-cylinder variations that make it difficult to optimize fuel and air intake variables consistently. Uneven heating can also distort cylinders to the point that piston rings don't consistently seal the combustion chamber. Finally, the limited cooling capacity requires that air-cooled engines stay at fuel-rich conditions when operating near full power.

While air-cooled engines account for about 9 percent of Large SI engine sales, their use is concentrated in a few specialized applications. Almost all of these are portable (non-motive) applications with engine operation at constant speeds (the speed setting may be adjustable, but operation at any given time is at a single speed). Many applications, such as concrete saws and chippers, expose the engine to high concentrations of ambient particles that may reduce an engine's lifetime. These particles could also form deposits on radiators, making water-cooling less effective.

2.2.1.5 Forklift Truck Manufacturing

As noted above, forklifts are the most common application of Large SI engines. Forklifts are self-propelled trucks equipped with platforms that can be raised and lowered. These trucks are used for lifting, stacking, retrieving, and transporting materials and are typically powered by either LPG, gasoline, diesel, or an electric motor. It is estimated that 80 percent of the forklift trucks in these classes operate on LPG.[47] The industry classifies forklifts in six categories, and the types of forklifts with Large SI engines are those classified as Class 4, 5, and 6. They represent those forklift truck classes that may be affected by the emissions control program. Descriptions of Class 4, 5, and 6 forklifts are as follows[48]:

- **Class 4**. Internal Combustion (IC) Engine Trucks - fork, counterbalanced, cushion tire, rider trucks;
- **Class 5**. IC Engine Trucks - fork, counterbalanced, pneumatic tire, rider trucks; and
- **Class 6**. Electric and IC Engine Tractors - sit down rider, draw bar pull.

The major difference between Class 4 and Class 5 forklifts is the type of tire installed. Pneumatic tires allow forklift trucks to be operated on varied terrain, while cushion tires are more suitable for flat floor surfaces. All of these forklifts allow for the operator to sit down, thus reducing operator fatigue or strain. Generally speaking, forklifts may differ in their design, maximum lift capacity, location of the lift operator, type of tires installed, and by the type of fuel used.

The costs of producing forklift trucks fall into three major categories: capital expenditures, labor costs, and the costs of materials. Capital expenditures include the manufacturer's costs of equipment and its installation; labor costs include the producer's costs associated with employees wages and benefits; and the costs of materials are the costs of tangible and intangible inputs such as internal combustion (IC) engines, steel for the truck frame, tires, rubber hosing and belting, counterbalances, and energy. Table 2.2-1 shows the historical production costs for the industrial truck, tractor, trailer, and stacker machinery manufacturing industry which includes forklift manufacturers. This industry is identified by Standard Industrial Code (SIC) 3537 and the North American Industrial Classification System (NAICS) Code 333924.

U.S. Department of Commerce statistics, set out in Table 2.2-1, show that the average value of shipments (VOS) for this industry over the 1992 to 1999 time period is equal to approximately $4.7 billion, with the highest value of shipments occurring in 1998. The cost of materials for this industry is equal to an average of almost $3 billion (64 percent of VOS). The average cost of labor is approximately $746 million (16 percent of VOS), while capital expenditures are equal to an average value of $93 million (2 percent of VOS). Examination of this data clearly shows that capital expenditures represent the smallest share of the value of shipments while the cost of materials represents the largest share.

Table 2.2-1
Value of Shipments (VOS) and Production Costs for the SIC and NAICS Codes that Include Forklift Manufacturers*, 1992 - 1999 [49,50,51,52,53,54,55]

		VOS	Payroll		Cost of Materials		Total Capital Expenditures	
Year	Industry Code	($$10^6$)	($$10^6$)	% of VOS	($$10^6$)	% of VOS	($$10^6$)	% of VOS
1992	SIC 3537	$2,754	$499	18%	$1,701	62%	$58	2%
1993	SIC 3537	$3,200	$592	19%	$1,984	62%	$43	1%
1994	SIC 3537	$4,054	$628	15%	$2,700	67%	$71	2%
1995	SIC 3537	$4,970	$723	15%	$3,251	65%	$94	2%
1996	SIC 3537	$4,866	$742	15%	$3,076	63%	$107	2%
1997	NAICS 333924	$5,538	$894	16%	$3,612	65%	$140	3%
1998	NAICS 333924	$6,248	$944	15%	$4,112	66%	$104	2%
1999	NAICS 333924	$5,597	$942	17%	$3,429	61%	$127	2%
	Average	$4,653	$746	16%	$2,983	64%	$93	2%

* Value of Shipments, Payroll, Cost of Materials, and Total Capital Expenditures are in nominal U.S. dollars.

2.2.2 The Demand Side

This section provides information about the uses and consumers of Large SI engines and forklift trucks. The various industrial sectors in which forklifts are used and the substitute products for forklifts are also discussed.

Generally speaking, industrial SI equipment is considered a final good while Large SI engines are referred to as intermediate goods. This is because the engines are manufactured to be used as inputs to the production of industrial SI equipment. Consumers in the marketplace demand industrial equipment which may contain Large SI engines, therefore their demand for Large SI engines is derived from their demand for industrial equipment.

Manufacturers of industrial equipment have three options to obtain the SI engines they use for equipment production. Their first options is to produce the SI engines used in their final products. The second option is to purchase a partially finished engine and add on the fuel system and perform the engine calibration in-house. The third options is to purchase a completed engine and “drop” it in their equipment without modification. When equipment companies purchase Large SI engines as an input to their production, they are considered the immediate consumers of Large SI engines. However, if equipment manufacturers choose to produce Large SI engines as inputs for their production of equipment, they have vertically integrated the production of a vital input, SI engines, into their overall production process. Though they consume the engines in the production of industrial equipment, they are, in this case, the suppliers of these engines via the final product.

In the case of forklifts, engines are commonly purchased from outside companies. However, the design and assembly of these engines may be completed in-house (i.e., adding the fuel system and calibrating the engine). Sometimes the forklift manufacturer is the designer of the engines, but in other cases, the forklift manufacturer may rely on its parent company to work on engine design while it focuses exclusively on forklift production. This secondary arrangement is common in large companies which may contain a subsidiary producer of forklift trucks. Because engine designs may be specific, contractual arrangements may be made between engine manufacturers and forklift producers so as to keep the supply of engines consistent.

2.2.2.1 Uses of Forklifts

The main function of forklift trucks is to lift and transport materials. Class 4, 5, and 6 forklifts are used in indoor settings, such as warehouses and stock rooms or in some outdoor settings. Table 2.2-2 shows the population of forklift trucks by industry sector for the year 1995, the most recent year for which industry data is available. The manufacturing sector uses the largest share of forklifts followed next by wholesale trade. Together, these two industry sectors accounted for over 60 percent of the U.S. total forklift population in 1995. This estimate is based on industry shipments and allows for scrappage of older units.

Table 2.2-2
1995 Class 4, 5, and 6 Forklift Population by Industry Sector[56]

Industry Sector	Population	Percent Share (%)
Manufacturing	196,985	40.3%
Wholesale Trade	100,721	20.6%
Transportation, Communication, and Utilities	68,785	14.1%
Services	46,675	9.5%
Retail Trade	32,919	6.7%
Construction	29,497	6.0%
Other	13,757	2.8%
Total	489,339	100%

2.2.2.2 Substitution Possibilities for Forklifts

The most common substitute for Class 4, 5, and 6 IC engine forklifts are electric motor forklifts, which fall into Classes 1, 2, and 3. Descriptions of these forklifts are as follows[57]:

- **Class 1**. Electric Motor Rider Trucks;
- **Class 2**. Electric Motor Narrow Isle Trucks; and

- **Class 3**. Electric Motor Hand Trucks.

Electric-powered forklifts are also used for lifting, transporting, and stacking of materials, but they differ in design and lift capacity from Class 4, 5, and 6 lift trucks. Design differences may lead a consumer to choose one type of forklift over another. For example, narrow isle trucks are commonly found in warehouses that are designed to use less floor space and rely more on vertical stacking. Rider-type forklift trucks are used when significant amounts of material must be moved or where operator fatigue may be an issue. Hand trucks are used for lighter loads and are operated using a handle.[58] Generally, electric forklifts have lower material-handing capacity.

One advantage of Class 1, 2, and 3 forklifts is that they do not produce exhaust fumes while in operation, thus making them well suited to indoor operations. However, electric forklifts rely on batteries that must be recharged which may lead to times where forklifts are not available. Changing out spent batteries to reduce recharge time is not generally practical because these batteries are expensive (as much as $10,000 or more each) and can weigh 1,000 lbs. While electric forklifts can operate for about 8 hours on a charge, LPG forklifts can operate for about 12 hours before refueling. Consequently, electric forklifts may be a practical alternative only in some applications.

Aside from electric powered forklifts, other modes of transporting materials may be considered. For lighter loads, non-motorized hand pallet trucks and stacker machinery may be acceptable substitutes. They are less expensive but have low load capacities. These types of equipment also rely more heavily on manual labor.

2.2.2.3 Customer Concerns

As illustrated in Table 6.6.2.1, most Large SI engines are used in industrial applications. These industrial customers have historically been most concerned about the cost of the engine and equipment, and about reliability. In many cases, equipment users value uniform and familiar technology because these characteristics simplify engine maintenance. As described in Chapter 5, equipment users have largely ignored the potential for improving fuel economy when they make their purchase decisions. As a result most Large SI engines being sold today have relatively simple carburetor technology that is similar to automotive technology of the early 1960s.

Another user concern relates to emissions. A large number of these engines are operated indoors or in other areas with restricted airflow much of the time. For these applications, customers generally want engines with lower CO emissions. Consequently, most engines used in these applications are fueled with LPG or CNG. However, calibration or maintenance problems in the field can cause dangerously high CO levels in these engines. Occasionally customers purchase engines equipped with exhaust catalysts to protect operators from exposure to high emission levels.

2.2.3 Industry Organization

It is important to gain an understanding of how the Large SI equipment and engine industries may be affected by the emission control program. One way to determine how increase costs may affect the market is to examine the organization of each industry. This section provides data to measure the competitive nature of the forklift and Large SI engine industries and lists manufacturers of these equipment and engines. It should be noted that while forklift manufacturers will be affected by changing engine designs, only those companies that certify their engines with EPA will be directly regulated.

This section does not contain detailed information on non-forklift application. While these other sectors will be affected by the control program, it is not practical to report detailed information for each.

2.2.3.1 Market Structure

Market structure is of interest because it determines the behavior of producers and consumers in the industry. In perfectly competitive industries, no producer or consumer is able to influence the price of the product sold. In addition, producers are unable to affect the price of inputs purchased for use in production. This condition is most likely to hold if the industry has a large number of buyers and sellers, the products sold and inputs used are homogeneous, and entry and exit of firms is unrestricted. Entry and exit of firms are unrestricted for most industries, except in cases where the government regulates who is able to produce output, where one firm holds a patent on a product, where one firm owns the entire stock of a critical input, or where a single firm is able to supply the entire market. In industries that are not perfectly competitive, producer and/or consumer behavior can have an effect on price.

Concentration ratios (CRs) and the Herfindahl-Hirschman index (HHI) can provide some insight into the competitiveness of an industry. The U.S. Department of Commerce reports these ratios and indices for the six digit NAICS code level for the year 1997, the most recent year available. Table 2.2-3 provides the four- and eight-firm concentration ratios (CR4 and CR8, respectively), and the Herfindahl-Hirschman index for the industrial truck, tractor, trailer, and stacker machinery manufacturing industry, the industry that includes producers of forklifts. This industry is represented by NAICS code 333924. Concentration ratios are provided in percentage terms while HHI are based on a scale formulated by the Department of Justice.

The criteria for evaluating the HHI are based on the 1992 Department of Justice Horizontal Merger Guidelines. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive). In general, firms in less concentrated industries have more ability to influence market prices. Based on these criteria, the industry that produces forklifts can be modeled as perfectly competitive for the purposes of the economic impact analysis, since their HHI is 503.

Table 2.2-3
Measures of Market Concentration for the NAICS Code that Includes Forklift Manufacturers, 1997 [59]

Description	CR4	CR8	HHI	VOS ($\$10^6$)	Number of Companies
NAICS 333924	38.5	52.3	503	$5,538.33	434

2.2.3.2 Large SI Engine and Forklift Manufacturers

Using data from Power Systems Research for the period 1994-96, we have identified seven principal manufacturers of Large SI engines. These are listed in Table 2.2-4, along with their average annual sales volume. This table shows that sales volumes are relatively evenly distributed among these seven manufacturers. The figures for "other" manufacturers presents aggregated data from four additional companies: Volkswagen, Westerbeke, Hercules, and Chrysler. While the market has changed over recent years, with some manufacturers dropping out of the market, General Motors, Mitsubishi Motors, Ford Power Products, and Nissan Industrial Engines continue to have roughly equal shares and represent between 60 and 70 percent of the annual sales of these engines in the United States.

Table 2.2-4
Engine Sales by Manufacturer (1994-1996)

Manufacturer	Average Annual Sales	Distribution
General Motors	19,500	19%
Mitsubishi Motors	15,600	15%
Ford Power Products	14,000	14%
Nissan Industrial Engines	13,800	13%
Wis-Con Total Power	12,100	12%
Toyota	11,800	12%
Mazda	8,200	8%
Other	7,200	6%
Total	102,300	100%

Source: Power Systems Research Database

The degree to which engine manufacturers offer integrated engine and equipment models is an important factor in determining how companies address the need to redesign their products. Companies that use their own engine models to produce equipment can coordinate the engine design changes with the appropriate changes in their equipment models. The principal integrated manufacturers (Nissan, Mitsubishi, and Toyota) all produce forklifts. About 40 percent of Large SI equipment sales are from integrated manufacturers.

Other forklift manufacturers have also been responsible for varying degrees of engine design. Engine design expertise among these companies is so prevalent that some forklift manufacturers may assume responsibility for certifying their engines, even though they buy the engines mostly assembled from other manufacturers.

EPA has identified at least fourteen forklift manufacturers that use Large SI engines. The majority of these companies produce Class 4 and 5 forklifts, though there are a handful that manufacture Class 6 forklifts. Table 2.2-5 provides a listing of the forklift manufacturers and their total annual sales (including sales abroad) for the most current year for which data were available (2000 or 2001). The table shows that the companies range in size based on their annual sales.

Table 2.2-5
Annual Sales for Forklift Manufacturing Companies, 2000/2001 [60,61,62,63]

Company	Annual Sales ($\$10^6$)
NACCO Materials Handling Group (owns Hyster and Yale)	$1,292
Clark Material Handling Company	$539
Mitsubishi Caterpillar Forklift America, Inc.	$172
Nissan Forklift Corporation, North America	$86
Toyota Industrial Equipment Manufacturing	$83
Hyundai Construction Equipment - Material Handling Division	$80
TCM Manufacturing USA	$50
Komatsu Forklift USA, Inc.	$30
Kalmar AC, Inc.	$27
Linde Lift Truck Corporation	$26
Drexel Industries, Inc.	$26
Tailift USA, Inc.	$10
Blue Giant	$9
Daewoo Heavy Industries America	$5

2.2.4 Markets

This section examines the historical market statistics for the forklift manufacturing industry. Historical data on the quantity of domestic shipments and some price data of IC engine forklifts are provided. The quantity and values of exports and imports of non-electric forklift trucks are presented as well.

2.2.4.1 Quantity and Price Data

Historical market data on the quantity of U.S. shipments of Class 4, 5, and 6 forklifts are provided in Table 2.2-6 and were obtained from the Industrial Truck Association Membership Handbook (2002). As this table shows, there has been an overall increasing trend in the quantity of forklifts produced in the U.S. with an overall net increase of 118 percent from 1980 to 2000 and an average increase of just under 7 percent per year. During the 1990s, shipments increased from almost 48,000 in 1990 to approximately 73,000 in 1995, but then dipped in 1996 to just above 60,000. Since 1996, the general increasing trend in the quantity of SI engine forklifts manufactured in the U.S. continued with a relatively small dip in 1999. For the purpose of this economic impact analysis, we used 65,000 forklifts as our baseline quantity of forklifts produced in 2000, based on production data for the past 10 years. For future year projections, we used the growth rates contained in our NONROAD model.

Table 2.2-6
U.S. Shipments of Internal Combustion
Class 4, 5, and 6 Forklifts, 1980 - 2000 [64]

Year	Quantity of Shipments	Year	Quantity of Shipments
1980	39,448	1991	38,406
1981	31,885	1992	46,183
1982	18,553	1993	48,947
1983	26,245	1994	65,027
1984	45,338	1995	72,685
1985	47,844	1996	60,287
1986	46,195	1997	64,946
1987	47,945	1998	80,554
1988	48,535	1999	74,994
1989	55,104	2000	85,993
1990	47,702	Average Annual Growth Rate = 6.7%	

Forklift truck prices can vary a great deal depending on their class, the manufacturer, the model type, and selected options. Pricing data on various Class 4 and 5 forklift models were obtained from the Handbook of New and Used Equipment Values - IC Lift Trucks (Equipment Watch, 2001). Current retail prices for various IC forklifts with no options for the year 2001 varied from a low of $17,000 up to well over $100,000 for high end models. However, most models were priced in the range of $25,000 to $50,000.

2.2.4.2 Foreign Trade

Export and import values and quantities for non-electric forklifts presented in Table 2.2-7 show increasing trends since 1989. Based on this information, the U.S. is a net importer of forklifts as its value and quantity of imports exceeds it value and quantity of exports. Note, however, that U.S. domestic production of forklifts far outweighs the quantity it imports. A closer examination of the export value and quantity data show that while U.S. exports generally increased over the 1989 to 2001 time period, there was a sharp decline in export quantity and value in 1996. Exports of forklifts went from a total value of $194.3 million in 1995 to about $91 million in 1996 (a similar decline is evident in the quantity of forklifts). Since 1996, both the value and quantity of exports has increased with a slight dip occurring in 2001. U.S. imports of forklifts has also shown a general increase in both value and quantity, however again, in 2001 a slight dip is evident.

The main importers of non-electric forklifts, related trucks, and parts of forklifts to the U.S. are Japan, Canada, and the United Kingdom and the main countries the U.S. exports its forklifts to are Canada, Mexico, and the United Kingdom.[65]

Table 2.2-7
Import and Export Quantities and Values* for Non-Electric Self-Propelled Forklift and Other Trucks, 1989 - 2001 [66]

Year	Export Value ($$10^6$)	Export Quantity	Import Value ($$10^6$)	Import Quantity
1989	$113	7,065	NA	NA
1990	$142	7,651	NA	NA
1991	$148	8,302	NA	NA
1992	$146	9,511	NA	NA
1993	$144	12,762	NA	NA
1994	$196	11,277	$301	19,496
1995	$194	10,131	$389	22,824
1996	$91	4,963	$375	19,214
1997	$146	8,670	$459	21,820
1998	$162	9,890	$611	29,251
1999	$150	11,526	$574	26,741
2000	$190	16,208	$612	30,751
2001	$168	12,768	$507	23,381
Average	$153	10,056	$294**	14,883**

[a] Values are in nominal dollars.
[b] Average is computed for the years 1994 through 2001.

2.3 Snowmobile Market

Snowmobiles are normally one or two passenger vehicles that are used to transverse over snow-covered terrain. They have a track in the rear similar to that of a bulldozer and runners (similar to skis) in the front for steering. Snowmobiles are used primarily for recreational purposes. However, a small number of them are produced and used for utility purposes, such as search and rescue operations. Annual sales of snowmobiles in the U. S. have varied dramatically over the years. Over 140.6 million units were sold in the U. S. in 2001.[67]

2.3.1 The Supply Side

This section provides a description of snowmobiles and their engines, the major inputs used to manufacture this equipment, and the costs of production.

2.3.1.1 Product Types

There are several types of snowmobiles on the market. Snowmobiles types range from children's models with very low horsepower to high-powered machines with engine sizes approaching 1000 displacement cc. Snowmobiles are designed to appeal to a variety of consumers including those who wish to cover rough mountainous terrain, those who seek speed, those who wish to tour the countryside and the novice snowmobiler. Snowmobiles are offered in one-seat and two-seat models and in luxury and low-cost varieties. Snowmobile manufacturers seek to appeal to a wide range of potential snowmobile riders. This section will describe a few of the components of the models on the market. There are a variety of engine options including two-stroke or four-stroke, air or water cooled, and various engine displacements. Options include electric start, reverse, specialized paints, and other items. For a more complete description of typical snowmobile attributes see Section 9.4.

2.3.1.2 Engine Design and Populations

The vast majority of snowmobiles sold in the U.S. are powered by two-stroke engines currently. Engine displacements range from 60 cc for an entry-level youth model to 998 cc for a high-performance model. Based upon PSR snowmobile production data, snowmobiles produced have been trending towards higher engine sizes with the average engine size increasing over 17 percent between the period 1990 and 2000. In 1996 over 44 percent of the snowmobiles produced had engine sizes less than 500 cc displacement. In 2000, this percentage had dropped to 23 percent. In general the larger the engine size, the more powerful for the 2-stroke engines that dominate the snowmobile market today. The average engine size in 2002 was 570 cc displacement.[68]

The number of models produced for a given engine size for the four major snowmobile manufacturers is shown in Table 2.3-1.

Table 2.3-1
Engine Displacement for Major Snowmobile Manufacturers in the U.S. Market in 2000[69]

Manufacturers	≤300cc	≤500cc	<700cc	700-1000cc
Arctic Cat, Inc.	852	14,233	41,253	8,317
Bombardier (Ski Doo)	2,638	23,507	20,017	11,973
Polaris Industries	2,533	21,585	34,067	14,276
Yamaha	0	10,615	16,483	6,085
Total	6,023	69,940	111,820	40,651

* Production data were taken from OELINK Database owned by Power Systems Research.

2.3.1.3 Two-Stroke vs Four-Stroke Cycle Engine Usage

The majority of snowmobiles are equipped with 2-stroke engines. For the 2003 models currently available for sale, nine 4-stroke models are available. Each of the manufacturers offers 4-stroke models in their current sales inventory. For more details see Section 9.4.

2.3.1.4 Production Costs of Snowmobiles

Production costs for snowmobiles are not readily available. In lieu of cost of production data for snowmobiles specifically, a discussion of the cost of production data for NAICS 366999 Other Transportation Equipment Manufacturing is presented. This category includes snowmobiles, ATVs, golf carts, and other miscellaneous transportation equipment. As Table 2.3-2 shows, the average value of shipments (VOS) for these industries over the 1992 to 2000 time period is equal to approximately 4.5 billion dollars, with the highest value of shipments occurring in 2000. The cost of materials for this industry is equal to an average of about 3 billion dollars (65 percent of VOS). The average cost of labor is approximately 549 million (12 percent of VOS), while capital expenditures are equal to an average value of 97 million (2 percent of VOS). Examination of these data clearly shows that capital expenditures and payroll represent the smallest shares of the value of shipments while the cost of materials represents the largest share.

Table 2.3-2
Value of Shipments (VOS) and Production Costs for the SIC and NAICS Codes that Includes Snowmobile Manufacturers, 1992 - 2000 [70,71,72,73,74]

		VOS	Payroll		Cost of Materials		New Capital Expenditures	
Year	Industry Code	($$10^6$)	($$10^6$)	% of VOS	($$10^6$)	% of VOS	($$10^6$)	% of VOS
1992	SIC 3799	3,087	449	15%	1,969	64%	62	2%
1993	SIC 3799	3,807	514	14%	2,422	64%	86	2%
1994	SIC 3799	3,947	469	12%	2,611	66%	98	2%
1995	SIC 3799	4,539	512	11%	3,056	67%	86	2%
1996	SIC 3799	5,179	570	11%	3,368	65%	103	2%
1997	NAICS 336999	4,437	496	11%	2,803	63%	97	2%
1998	NAICS 336999	5,033	578	11%	3,236	64%	122	2%
1999	NAICS 336999	5,645	643	11%	3,766	67%	106	2%
2000	NAICS 336999	6,245	714	11%	4,195	67%	117	2%
	Average	4,568	549	12%	3,047	65%	97	2%

* Value of Shipments, Payroll, Cost of Materials, and Total Capital Expenditures are in nominal U.S. dollars

2.3.2 The Demand Side

This section provides information on the uses of snowmobiles, various substitute products on the market, and information concerning consumers who purchase snowmobiles.

2.3.2.1 Uses of Snowmobiles

There are a variety of snowmobile types currently produced and tailored to a variety of riding styles. The majority of the overall snowmobile market is made up of high performance machines. These snowmobiles have fairly high powered engines and are very light, giving them good acceleration speed and handling. The performance sled come in several styles. Cross country sleds are designed for aggressive trail and cross country riding. Mountain sleds have longer tracks and wider runner stance for optimum performance in mountainous terrain. Finally, muscle sleds are designed for top speeds (in excess of 120 miles per hour) over flat terrain such as frozen lakes. Performance snowmobiles are generally designed for a single rider.

The second major style of snowmobile is designed for casual riding over groomed trails. These touring sleds are designed for one or two riders and tend to have lower powered engines than performance snowmobiles. The emphasis in this market segment is more on comfort and convenience. As such, these sled feature more comfortable rides than performance machines and tend to have features such as electric start, reverse, and electric warming hand grips.

The last and smallest segment of the snowmobile market is the utility sled segment. Utility snowmobiles are designed for pulling loads and for use in heavy snow. Thus the engines are designed more for producing torque at low engine speeds, which typically corresponds to a reduced maximum speed of the snowmobiles. Utility snowmobiles are common in search and rescue operations.

A typical snowmobile lasts thirteen years and travels approximately 17,000 miles over its lifetime. The average snowmobile is used 57 hours per year.[75]

2.3.2.2 Substitution Possibilities

A number of substitute products to snowmobiles exist. Consumers can substitute across off-road recreational vehicles. However, ATVs and off-highway vehicles may not be used safely in the snow. Snow coaches are a substitute motorized product. Consumers may be interested in engaging in outdoor activities, but may instead consider doing a non-motorized activity. For example, consumers who are interested in being outside in the snow may engage in skiing or sledding. Recreational indoor activity of many types are substitute possibilities for snowmobile riding.

2.3.2.3 Customer Demographics and Customer Concerns

Based upon ISMA data, the average snowmobile owner is 42 years old, and had an average annual income of $68,000 in 2001. The average snowmobile rider has 18 years experience in riding. The majority of snowmobile owners are married. Approximately 63 percent of riders trailer their snowmobiles to go riding.[76]

Good performance is very important to snowmobilers. This is especially true for the performance segment of the market, where high power and low weight are crucial for the enjoyment of the performance snowmobile enthusiast. The performance snowmobile segment is driven by a constant demand for more power and lower weight. In the touring segment of the market, performance in terms of power and weight is somewhat less important but still significant. In all snowmobile market segments, durability and reliability are very important to the customer.

The price of a snowmobile produced by the four major manufacturers currently ranges from about $3,700 for entry level models to around $12,000 for some high performance models. The average snowmobile price in 2001 was $6,360. Some of the high performance snowmobiles produced by the small manufacturers can approach $20,000, but this is an extremely small niche market. Since snowmobiles are a discretionary purchase, price is a factor in the consumers decision to purchase.

2.3.3 Industry Organization

Because there are costs associated with the emission control program, it is important to determine how the snowmobile industry may be affected. Industry organization is an important factor which affects how a market may react to regulatory costs. This section provides a description of the organization of the snowmobile industry.

2.3.3.1 Market Structure

Market structure is of interest because it determines the behavior of producers and consumers in the industry. In perfectly competitive industries, no producer or consumer is able to influence the price of the product sold. In addition, producers are unable to affect the price of inputs purchased for use in production. This condition is most likely to hold if the industry has a large number of buyers and sellers, the products sold and inputs used are homogeneous, and entry and exit of firms is unrestricted. Entry and exit of firms are unrestricted for most industries, except in cases where the government regulates who is able to produce output, where one firm holds a patent on a product, where one firm owns the entire stock of a critical input, or where a single firm is able to supply the entire market. In industries that are not perfectly competitive, producer and/or consumer behavior can have an effect on price.

Concentration ratios (CRs) and the Herfindahl-Hirschman index (HHI) can provide some insight into the competitiveness of an industry. The U.S. Department of Commerce reports these ratios and indices for the six digit NAICS code level for the year 1997, the most recent year available. Table 2.3-3 provides the four- and eight-firm concentration ratios (CR4 and CR8, respectively), and the Herfindahl-Hirschman index for the NAICS code 336999, Other Transportation Equipment Manufacturing, the industry category that includes producers of snowmobiles. Note that the concentration ratio is reported in percentage terms while the HHI is based on a scale developed by the Department of Justice. For this industry the CR4 was 50.7 percent and the CR8 was 75.3 percent.

The criteria for evaluating the HHI are based on the 1992 Department of Justice Horizontal Merger Guidelines. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive). In general, firms in less concentrated industries have more ability to influence market prices. Based on these criteria, the NAICS category that includes firms that produce snowmobiles can be considered unconcentrated or more competitive.

Table 2.3-3
Measures of Market Concentration for the NAICS Code that Includes NAICS 336999 Manufacturers, 1997 [77]

Description	CR4	CR8	HHI	VOS ($\$10^6$)	Number of Companies
NAICS 336999	50.7	75.3	885.2	$4,436,679	349

However, it is important to recognize that four producers dominate the snowmobile industry or produce 99 percent of the worldwide snowmobiles produced and sold. This information suggests that snowmobile manufacturing is highly concentrated with four manufacturers dominating the market. However, when one considers firm behavior within the industry and the availability of numerous product substitutes, the picture alters somewhat. While snowmobile manufacturing is concentrated, snowmobiles represent a small fraction of total recreational products available in the market place.

Market structure is important to assessing the potential impacts of a regulation on an industry because it determines the behavior of producers and consumers within the industry. Economists often estimate concentration ratios for the subject market or industry to assess the competitiveness. More (less) concentrated markets are considered to be less (more) competitive. The extremes are defined by perfect competition (many buyers/seller with no influence over price) and monopoly (one seller with control over setting price). Between these two extremes are varying degrees of imperfect competition, or oligopoly, that depend upon different assumptions of strategic behavior among sellers within the market or industry. The competitiveness will depend upon the definition of the subject market or industry with those being more (less) broadly defined demonstrating more (less) competition. For example, the "snowmobile" market is dominated by four major producers and may be considered less competitive. However, there are likely to be many substitutes for snowmobiles when considering the broader "recreational vehicles" or "recreational activities" markets. These substitutes increase the competitive nature of the market or industry. In previous regulatory analysis, the Agency has modeled the imperfectly competitive nature of pharmaceuticals (product differentiation) and cement (regional barriers to entry) where there were commonly accepted and researched approaches. Rather than add uncertainy to model outcomes by speculating on the strategic interactions of producers here, we chose to model the markets as perfectly competitive. Generally speaking, this assumption will tend to understate the price and output changes associated with regulation and may overstate the profit loss of producers; however, the extent of the bias is unknown and direction may vary by producer.[78]

2.3.3.2 Snowmobile Manufacturers

Manufacturers of snowmobile were formerly classified under the SIC code 3799 and are now classified under NAICS code 336999, Other Transportation Equipment Manufacturing. The

Small Business Administration (SBA) uses SIC/NAICS categories to classify businesses as large or small, depending on the number of employees or sales criteria. Snowmobile manufacturers have the NAICS sub-classification 3369993414 and must have fewer than 500 employees to be considered a small business by SBA. Snowmobile wholesale companies may also be impacted by this regulation. Wholesale dealers of snowmobiles are categorized as NAICS classification 421110 - Automobile and Other Motor Vehicle Wholesales, and are considered small business if they have fewer than 100 employees.

There are four major manufacturers of snowmobiles that account for almost the entire U.S. market. These manufacturers are Arctic Cat, Bombardier (Ski Doo), Polaris and Yamaha. Polaris is the largest snowmobile manufacturer by sales volume, followed by Arctic Cat, Bombardier, and Yamaha. There are less than five snowmobile manufacturers that combined make up significantly less than one percent of the U.S. snowmobile market. These snowmobile manufacturers specialize in high performance snowmobiles and other unique designs (such as stand-up snowmobiles).

Bombardier and Yamaha produce the engines used in the snowmobiles they sell. In contrast, Polaris and Arctic Cat purchase engines for the snowmobiles they sell. Arctic Cat typically purchases Suzuki engines, while Polaris purchases engines made by Fuji Corporation.

2.3.4 Snowmobile Retailers and Rental Firms

In contrast to the small number of manufacturers producing snowmobiles, there are over 1,500 registered snowmobile dealers in the United States according to ISMA data. Approximately the same number operate in Canada and Scandinavia. These firms typically do not sell snowmobiles exclusively, but also sell other recreational vehicle products such as ATVs and motorcycles. Snowmobile retailers are included in NAICS category 441229 - All Other Motor Vehicle Dealers, and are considered small business if annual sales revenues are less than $6.0 million. In additional to retailers, rental firms exist that purchase snowmobiles to rent to the occasional snowmobile rider. These firms are included in NAICS category 532292 - Recreational Goods Rental, and are considered small business if the firm experiences sales less than $6.0 million. Potentially, both retailers and rental firms may be impacted by the regulation to the extent that the price of the snowmobiles the firms sell or rent increase.

2.3.5 Markets

This section examines the historical market data for the snowmobile industry. Historical data on the quantity of domestic shipments and price data of snowmobiles are provided.

2.3.5.1 Quantity and Price Data

Historical market data on the quantity of snowmobiles sold in the U.S. are provided in Table 2.3-4. Data were obtained from ISMA.[79] As this table shows, there has been an overall increasing trend in the quantity of snowmobiles sold in the U.S. with an average annual increase of 6 percent from 1990 to 2001. However, annual sales declined in 1991 and 1998 through 2000. Sales of snowmobiles increased more than 76 percent between the years 1990 and 2001. Retail dollars sales increased, on average, by 11 percent annually from 1990 to 2001. Snowmobile retail dollars per unit have also increased, showing an annual average increase of 5 percent for the same period.

Table 2.3-4
U.S. Units Sold, Retail Dollars and Retail Dollars Per Unit
Snowmobiles, 1990 - 2001 [80]

Year	Unit Sales	% Change Unit Sales	Retail Dollars ($$10^6$)	% Change Retail Dollars	Retail Dollars/ Unit	% Change Retail Dollars/Unit
1990	80,000	---	$300.0	---	$3,750	---
1991	78,000	(3%)	$323.7	8%	$4,150	11%
1992	81,946	5%	$356.0	10%	$4,344	5%
1993	87,809	7%	$403.9	13%	$4,600	6%
1994	114,057	30%	$558.9	38%	$4,900	7%
1995	148,207	30%	$791.3	42%	$5,339	9%
1996	168,509	14%	$905.2	14%	$5,372	1%
1997	170,325	1%	$1,005.8	11%	$5,905	10%
1998	162826	(4%)	$975.1	3%	$5,988	1%
1999	147867	(9%)	$882.8	9%	$5,970	0%
2000	136,601	(8%)	$821.0	7%	$6,000	1%
2001	140,629	3%	$894.4	9%	$6,360	6 %
11-year Annual Average	137,889	6%	$747	11%	$5,698	5%
Change 1990 to 2001		76%		198%		70%

*Dollar values and percent changes of dollar values presented are nominal values.

2.3.5.2 Foreign Trade

In general, export and import data are not available for the snowmobile market. Data for SIC 3799 are available from the International Trade Commission. These data are presented on Table 2.4-6, Import and Export Quantities and Values for ATVs, 1989-2001, in Section 2.4, All-Terrain Vehicles, below. However, SIC 3799 includes snowmobiles, ATVs, golf carts and other transportation equipment. Thus the trade data is not specific to snowmobiles. World wide sales data for snowmobiles are presented in Table 2.3-5. During 2000 approximately 40 percent of total worldwide production was produced by Bombardier and Yamaha, foreign companies with the remainder of 60 percent produced by Arctic Cat and Polaris, domestic manufacturers.

Table 2.3-5
Worldwide Production, Sales, and Inventories of Snowmobiles 1990 - 2001[81]

Year	Worldwide Production (10^3 units)	Worldwide Retail Sales (10^3 units)	Worldwide Inventory (10^3 units)
1990	174.9	163.4	55.5
1991	157.2	153.0	59.7
1992	116.3	150.0	27.9
1993	146.0	158.0	16.0
1994	185.0	181.0	18.6
1995	231.5	227.4	22.6
1996	260.9	252.3	31.1
1997	273.7	260.7	44.2
1998	270.7	257.9	56.9
1999	231.7	230.9	57.7
2000	205.0	208.3	54.4
2001	190.3	208.5	36.1

2.4 All-Terrain Vehicles

All Terrain Vehicles (ATVs) are normally one-passenger open vehicles that are used for recreational and other purposes requiring the ability to traverse over most types of terrain. Most modern ATVs have four-wheels, and have evolved from three-wheeled designs that were first introduced in the 1970s. According to data provided by the Motorcycle Industry Council (MIC), production of ATVs sold in the U.S. has averaged about 390,000 units between 1996 and 2001. However, ATV sales have increased during that time to more than 880,000 units in 2001. ATVs therefore constitute the largest single category of non-highway recreational vehicles, though it is difficult to calculate the total vehicle population at any given point in time since many states do not require registration of ATVs.

2.4.1 The Supply Side

This section provides a description of ATVs and their engines, the major inputs used to manufacture this equipment, and the costs of production.

2.4.1.1 Product Types

There are several types of ATVs on the market. This section will describe a few of the components of the models on the market. There are a variety of engine options including two-stroke or four-stroke, air or water cooled, and various engine displacements. Options also include 5-speed manual or automatic transmissions.

2.4.1.2 Engine Design and Populations

The majority of ATVs sold in the U.S. are powered by single-cylinder, four-stroke cycle engines of less than 40 horsepower, operating under a wide variety of operating conditions and load factors. Engine displacements range from 50cc for an entry-level youth model to 660cc for a high-performance adult model, but more than three-fourths of them fall in the 200-500cc range.

In the year 2000, ATV manufacturers used 225,246 engines between 200cc and 300cc displacement (see Table 2.4-1). Of the engines produced, 64 percent were less than 400cc displacement and 84 percent were less than 500cc displacement . Over the past four years, production of engines with greater than 500cc displacement has increased from approximately 5 percent in 1996 to 16 percent in 2000.

Table 2.4-1
Engine Displacement for Major ATV Manufacturers in the U.S. Market in 2000[82]

Manufacturers	<200cc	200 - 300cc	300 - 400cc	400 - 500cc	200 - 700cc
Arctic Cat, Inc.	0	14,758	4,896	10,869	0
Honda	2,429	119,661	7,561	65,933	13,583
Kawasaki Motors	0	44,169	6,780	0	0
Polaris Industries	0	21579	54,834	6,689	62,144
Suzuki	0	9,346	0	1,740	0
Yamaha	7,635	15,733	26,977	21,743	0
Total	10,064	225,246	101,048	106,980	75,727

2.4.1.3 Two-Stroke vs Four-Stroke Cycle Engine Usage

Approximately 80 percent of all ATVs produced for U.S. consumption use four-stroke cycle engines. Of the six major manufacturers, only Polaris, Suzuki and Yamaha used two-stroke cycle engines at all. The remainder of the two-stroke engines in ATVs sold in U.S. are found in entry-level or youth models, which are imported from the Far East or assembled in this country from imported parts. In general, two-stroke engines are less expensive to produce than four-stroke engines, thus providing a marketing advantage in the youth and entry-level categories. We estimate that two-strokes make up roughly twenty percent of the market when the imported youth models are included.

2.4.1.4 Production Costs of ATVs

As Table 2.4-2 shows, the average value of shipments (VOS) for this industry over the 1992 to 1999 time period is equal to approximately 4.6 billion dollars, with the highest value of shipments occurring in 1999. The cost of materials for this industry is equal to an average of about 3 billion dollars (65 percent of VOS). The average cost of labor is approximately 549 million (12 percent of VOS), while capital expenditures are equal to an average value of 97 million (2 percent of VOS). Examination of these data clearly shows that capital expenditures and payroll represent the smallest shares of the value of shipments while the cost of materials represents the largest share.

Table 2.4-2
Value of Shipments (VOS) and Production Costs for the SIC and NAICS Codes that Includes ATV Manufacturers, 1992 - 2000 [83,84,85,86,87]

		VOS	Payroll		Cost of Materials		New Capital Expenditures	
Year	Industry Code	($$10^6$)	($$10^6$)	% of VOS	($$10^6$)	% of VOS	($$10^6$)	% of VOS
1992	SIC 3799	3,087	449	15%	1,969	64%	62	2%
1993	SIC 3799	3,807	514	14%	2,422	64%	86	2%
1994	SIC 3799	3,947	469	12%	2,611	66%	98	2%
1995	SIC 3799	4,539	512	11%	3,056	67%	86	2%
1996	SIC 3799	5,179	570	11%	3,368	65%	103	2%
1997	NAICS 336999	4,437	496	11%	2,803	63%	97	2%
1998	NAICS 336999	5,033	578	11%	3,236	64%	122	2%
1999	NAICS 336999	5,645	643	11%	3,766	67%	106	2%
2000	NAICS 336999	6,245	714	11%	4,195	67%	117	2%
	Average	4,568	549	12%	3,047	65%	97	2%

* Value of Shipments, Payroll, Cost of Materials, and Total Capital Expenditures are in nominal U.S. dollars.

2.4.2 The Demand Side

This section provides information on the uses of ATVs, various substitute products on the market, and the consumers who purchase ATVs.

2.4.2.1 Uses of ATVs

As noted above, ATVs are used for recreational and other purposes. They are mainly used for, riding on trails. Examples of non-recreational uses are for hauling and towing on farms, ranches or in commercial applications. Some ATVs are sold with attachments that allow them to take on some of the functions of a garden tractor or snow blower. ATVs are also used for competitive purposes, although not to the same extent as off-highway motorcycles.

2.4.2.2 Alternate Uses of ATV Engines

Although a few ATV engine lines have been used in other applications, such as some smaller on- and off-highway motorcycles, manufacturers have stated that ATV engines are normally designed only for use in ATVs. ATV engines may share certain components with motorcycles, snowmobiles and Personal Water Craft (PWC), but many major components such as pistons, cylinders and crankcases differ within given engine displacement categories.

2.4.2.3 Substitution Possibilities

Consumers can substitute across off-road recreational vehicles. An off-highway motorcycle as a substitute would allow the consumer to enjoy the same off-road recreation that they would receive with an ATV. Consumers may be interested in engaging in outdoor activities, but may instead consider doing a non-motorized activity. For example, consumers who are interested in being outside may engage in hiking, running, or riding a bicycle. These non-motorized options would allow the consumer to participate in outdoor activity, hence they may be considered substitutes for less intensive off-highway pastime.

2.4.2.4 Customer Concerns

Except for the competitive segment of the market, performance seems to be somewhat less important to ATV purchasers than it is to purchasers of snowmobiles or off-highway motorcycles. Most youth models, which form a significant portion of the market, are normally equipped with governors or other speed-limiting devices. Performance can be important for some of the higher-end adult models, but handling is also an important consideration, particularly when riding in dense wooded areas. Durability and reliability are also important to the customer, but perhaps not as important as price.

The price of an ATV can range from about $1,200 for an entry-level youth model to around $7,000 or more for a large, high performance machine. ATVs, like other recreational vehicles, are basically discretionary purchases, although utility may enter into the equation more often than in the case of off-highway motorcycles or snowmobiles. Cost is an important factor, particularly in the youth or entry-level segments of the market, and significant cost increases could cause people to spend their discretionary funds in other areas.

2.4.3 Industry Organization

Because there are costs associated with the emission control program, it is important to determine how the ATV industry may be affected. Industry organization is an important factor which affects how a market may react to regulatory costs. This section provides a description of the organization of the motorcycle industry.

2.4.3.1 Market Structure

Market structure is of interest because it determines the behavior of producers and consumers in the industry. In perfectly competitive industries, no producer or consumer is able to influence the price of the product sold. In addition, producers are unable to affect the price of inputs purchased for use in production. This condition is most likely to hold if the industry has a large number of buyers and sellers, the products sold and inputs used are homogeneous, and entry and exit of firms is unrestricted. Entry and exit of firms are unrestricted for most industries, except in cases where the government regulates who is able to produce output, where one firm holds a patent on a product, where one firm owns the entire stock of a critical input, or where a single firm is able to supply the entire market. In industries that are not perfectly competitive, producer and/or consumer behavior can have an effect on price.

Concentration ratios (CRs) and the Herfindahl-Hirschman index (HHI) can provide some insight into the competitiveness of an industry. The U.S. Department of Commerce reports these ratios and indices for the six digit NAICS code level for the year 1997, the most recent year available. Table 2.4-3 provides the four- and eight-firm concentration ratios (CR4 and CR8, respectively), and the Herfindahl-Hirschman index for the NAICS code 336999l, Other Transportation Equipment Manufacturing, the industry category that includes producers of ATVs. Note that the concentration ratio is reported in percentage terms while the HHI is based on a scale developed by the Department of Justice. For this industry the CR4 was 50.7 percent and the CR8 was 75.3 percent.

The criteria for evaluating the HHI are based on the 1992 Department of Justice Horizontal Merger Guidelines. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive). In general, firms in less concentrated industries have more ability to influence market prices. Based on these criteria, the NAICS category that includes firms that produce ATVs can be considered unconcentrated or more competitive.

Table 2.4-3
Measures of Market Concentration for the NAICS Code that Includes ATV Manufacturers, 1997 [88]

Description	CR4	CR8	HHI	VOS ($\$10^6$)	Number of Companies
NAICS 336999	50.7	75.3	885.2	$4,436,679	349

2.4.3.2 ATV Manufacturers

Manufacturers of ATVs were formerly classified under the Standard Industrial Classification (SIC)code 3799 and the North American Industrial Classification System (NAICS) code 336999, Other Transportation Equipment Manufacturing. These codes are used by the Small Business Administration (SBA) uses SIC/NAICS categories to classify businesses as large or small, depending on the number of employees or sales criteria. ATV manufacturers have the NAICS sub-classification 3369993101 and must have fewer than 500 employees to be considered a small business by SBA. In addition to manufacturers, there are a number of importers of ATVs, classified under NAICS code 42111, the code that also includes importers of automobiles, trucks, motorcycles and motor homes. To be classified as a small business by SBA for this NAICS code, an importer must have fewer than 100 employees.

Using data including the Power Systems Research (PSR) Database, Dun & Bradstreet (D&B) Market Identifiers Online Database, and information from the MIC identified 16 manufacturers and 17 importers of ATVs. ATV producers and importers are listed in Table 2.4-4. Six large manufacturers, Honda, Polaris, Kawasaki, Yamaha, Suzuki, and Arctic Cat accounted for approximately 98 percent of all U.S. ATV production in calendar year 2000.

Four of the six major ATV manufacturers, Honda, Kawasaki, Yamaha and Suzuki, are primarily automobile and/or on-highway motorcycle manufacturers who also produce ATVs, off-highway motorcycles, snowmobiles, personal water craft (PWC) and other non-highway vehicles. Polaris and Arctic Cat manufacture snowmobile, in addition to producing ATVs. Polaris also produces on-highway motorcycles and Arctic Cat produces PWC.

The 10 other manufacturers account for the remaining two percent of U.S. production in 2000. Only three of these are non-U.S.-owned. Of these remaining producers, five are classified as large businesses, and five as small businesses. Bombardier is a large Canadian snowmobile manufacturer that has recently entered the ATV market. Cannondale is a large American bicycle manufacturer that has recently begun production of ATVs as well. Hyosung and Tai Ling are large Far Eastern manufacturers, who also manufacture motorcycles and motor scooters (in the case of Hyosung). Roadmaster/Flexible Flyer is primarily a large bicycle and toy manufacturer but it also produces youth ATVs that are sold in large discount stores.

There are also some 17 firms that import ATVs. Thirteen of these are U.S.-owned. Dun and Bradstreet data on the numbers of employees are available for four of these companies, and indicate that these are small businesses according to the SBA definition. Since none of these had more than 40 employees and two had less than 20 employees, it seems safe to assume that the others are also small businesses according to the SBA definition. The 17 importers and 5 small manufacturers either import completed ATVs or assemble them in this country from imported parts.

Table 2.4-4
ATV Manufacturers/Importers

Firm Name	Type
ATK	IMPORTER
COSMOPOLITAN MOTORS	IMPORTER
D.R.R. INC.	IMPORTER
E-TON DISTRIBUTION LP	IMPORTER
HOFFMAN GROUP INC.	IMPORTER
J & J SALES	IMPORTER
JEHM POWERSPORTS	IMPORTER
KASEA MOTORSPORTS	IMPORTER
MANCO PRODUCTS	IMPORTER
MOTORRAD OF NORTH AMERICA	IMPORTER
PANDA MOTORSPORTS	IMPORTER
POWERGROUP INTERNATIONAL ALPHASPORTS	IMPORTER
REINMECH MOTOR COMPANY, LTD	IMPORTER
TRANSNATIONAL OUTDOOR POWER LLC	IMPORTER
TWS-USA, INC	IMPORTER
ULTIMAX LCC	IMPORTER
UNITED MOTORS OF AMERICA, INC	IMPORTER
AMERICAN SUNDIRO	MANUFACTURER
ARCTIC CAT, INC.	MANUFACTURER
BOMBARDIER	MANUFACTURER
CANNONDALE CORP - BEDFORD	MANUFACTURER
HONDA AMERICAN MANUFACTURING	MANUFACTURER
HYOSUNG MOTORS AND MACHINERY	MANUFACTURER
INTERNATIONAL POWERCRAFT	MANUFACTURER
KAWASAKI MOTORS CORPORATION	MANUFACTURER
KEEN PERCEPTION INDUSTRIES	MANUFACTURER
MOSS	MANUFACTURER
PANDA MOTORSPORTS	MANUFACTURER
POLARIS INDUSTRIES	MANUFACTURER
ROADMASTER /FLEXIBLE FLYER	MANUFACTURER
SUZUKI	MANUFACTURER
TAI LING MOTOR COMPANY	MANUFACTURER
YAMAHA MOTOR MANUFACTURING CORP.	MANUFACTURER

2.4.3.3 Engine Manufacturers

Four of the major ATV producers, Honda, Kawasaki, Yamaha and Suzuki, manufacture both engine and equipment. In addition to producing engines for itself, Suzuki manufactures engines for Arctic Cat, and in fact owns a significant amount of Arctic Cat common stock. Hyosung Motors and Machinery and the Tai Ling Motor Company also use Suzuki engines in their ATVs. Although Polaris produces some of its own engines, a substantial number are supplied by Fuji Heavy Industries, primarily an auto and truck manufacturer, and its U.S. subsidiary, Robin Industries. Polaris owns a substantial amount of Robin common stock.

Other engine manufacturers include Rotax, a subsidiary of Bombardier Inc., a large Canadian company. Bombardier/Rotax also produces engines for a wide variety of other applications, including snowmobiles, motorcycles, ATVs, personal water craft (PWC), utility vehicles and aircraft. A few small ATV manufacturers use Briggs or Kohler utility engines, but these are covered by EPA's Small Spark Ignition (SI) Engine regulations and are not included in this analysis.

2.4.4 Markets

This section examines the historical market data for the ATV industry. Historical data on the quantity of domestic shipments and price data of ATVs are provided. The quantity and values of imports and exports for ATVs are presented as well.

2.4.4.1 Quantity and Price Data

Historical market data on the quantity of ATVs sold in the U.S. are provided in Table 2.4-5. Data were obtained from the Motorcycle Industry Council (MIC). As this table shows, there has been an overall increasing trend in the quantity of ATVs sold in the U.S. with an average annual increase of 17 percent from 1990 to 2001. Sales of ATVs increased more than 600% between the years 1990 and 2001. Retail dollars increased, on average, by 22 percent from 1990 to 2001. This is due to the huge increase in production. Retail dollars per unit has also increased, showing an annual average increase of 5 percent for the same period. There was a steady rise of the retail dollars/unit over this time period.

Table 2.4-5
U.S. Units Sold, Retail Dollars and Retail Dollars Per Unit ATVs, 1990 - 2001 [89]

Year	Unit Sales	% Change Unit Sales	Retail Dollars ($\$10^3$)	% Change Retail Dollars	Retail Dollars/ Unit	% Change Retail Dollars/Unit
1990	134,619		$393.20		$2,921	
1991	125,056	(7%)	$371.32	(5%)	$2,969	2%
1992	144,332	15%	$449.42	21%	$3,114	5%
1993	162,307	12%	$563.18	25%	$3,470	11%
1994	189,328	17%	$770.52	37%	$4,070	17%
1995	277,787	48%	$1,282.47	66%	$4,617	13%
1996	317,876	14%	$1,530.97	19%	$4,816	4%
1997	359,397	13%	$1,759.77	15%	$4,896	2%
1998	429,414	19%	$2,155.02	22%	$5,019	3%
1999	545,932	27%	$2,805.70	30%	$5,139	2%
2000	648,645	19%	$3,343.15	19%	$5,154	0.3%
2001	880,000	12%	$3,734.91	12%	$5,123	-0.6%
Annual Average	383,154	17%	$1,596.64	22%	$4,276	5%

2.4.4.2 Foreign Trade

Export and import values and quantities for ATVs are presented in Table 2.4-6. This table shows that the export values started out on in an increasing trend for the first three years. Then in 1992, export value dropped by 64 percent and fluctuated between $73 million and $95 million, with the exception of the year 1997. Import quantity decreased until 1992 then remained between 34 thousand and 45 thousand through 2001. The import value decreased each year from 1989 to 1993, it dropped again in 1995 and maintained an increasing trend from 1996 to 2001. The import quantity generally decreased from 1989 to 1993 and started a general rebounding trend. Note that the data presented relates to SIC 3799 and includes ATVs, snowmobiles, golf carts and other transportation equipment.

Table 2.4-6*
Import and Export Quantities and Values for ATVs, 1989 - 2001 [90]

Year	Export Value ($$10^3$)	Export Quantity (10^3)	Import Value ($$10^3$)	Import Quantity (10^3)
1989	$169,881	161	$223,425	2,548
1990	$196,344	95	$156,239	2,486
1991	$209,003	75	$50,877	2,838
1992	$134,356	35	$31,786	1,854
1993	$75,876	40	$9,907	8
1994	$72,787	45	$13,549	11
1995	$85,976	43	$7,351	17
1996	$92,806	42	$9,272	19
1997	$136,357	45	$13,478	41
1998	$85,742	34	$19,174	37
1999	$91,335	42	$32,755	113
2000	$94,783	40	$48,433	178
2001	$89,381	42	$89,786	156
Average	$118,048	56	$54,310	793

*Values shown relate to SIC 3799, which includes ATVs, snowmobiles, golf carts, and other transportation products.

2.5 Off-Highway Motorcycles

Off-highway motorcycles, commonly referred to as "dirt bikes," are recreational vehicles designed specifically for use on unpaved surfaces. As such, they all have certain characteristics in common, such as a large amount of clearance between the fenders and the wheels, tires with aggressive knobby tread designs, and a lack of some of the equipment typically found on highway motorcycles (e.g., lights, horns, turn signals, and often mufflers). Thus they normally can not be licensed for on-highway use. There are a limited number of motorcycles, known as dual-purpose motorcycles, that can be used for both on- and off-highway purposes. These can be licensed for highway use, and so fall under the current highway motorcycle regulations, assuming that they are powered by engines of 50cc or larger displacement. Off-highway motorcycles are used for recreational riding, but substantial numbers are also used for competition purposes. Some in fact can be used for little else, e.g., machines that are designed for observed trials competition, which have no seats in the conventional sense of the term, and engine characteristics that are totally unlike those of most other motorcycles. Only a few thousand observed trials competition bikes are produced each year. Vehicles designed solely for competition are exempt from this rule. EPA's noise regulations also exempt any off-highway motorcycle that is designed and marketed solely for use in closed-course competition.

2.5.1 The Supply Side

This section provides a description of off-road motorcycles and engines, the major inputs used to manufacture this equipment, and the costs of production.

The motorcycle manufacturing process generally begins with the delivery of motorcycle engines and transmissions, from engine plants to the motorcycle assembly plant. At the plant, the engines and transmissions are matched to designated vehicles on the assembly line. Motorcycle engines are produced with 1 to 8 cylinders, with various configurations. Multi-cylinder engines are manufactured in three basic configurations: in-line, opposed, and V-type. Each of these refer to the position of one bank of cylinders in relation to the other. Motorcycles engines can be air or water cooled; 2-stroke or 4-stroke; carbureted or fuel-injected. Engines may be manufactured with variances in other design characteristics, including the number and placement of carburetors, cams, and valves.

2.5.1.1 Product Types and Populations

The number of off-highway motorcycles produced for sale in the U.S. averaged about 71,415 units between 1990 and 2001. As is the case with ATVs, off-highway motorcycle production increased considerably in later years, to more than 195,000 units in 2001 according to the Motorcycle Industry Council (MIC). Since many states do not require registration of off-highway motorcycles, it is difficult to estimate a total population of these vehicles operational at any given time.

As noted above, off-highway motorcycles can be used for recreational purposes or for competition. EPA defines vehicles that are "used solely for competition" as those with features (not easily removable from the vehicle) that would make the vehicle's use in other recreational activities unsafe, impractical, or highly unlikely.

Certain types of off-highway motorcycles are designed and marketed for closed-course competition. These are commonly known as "motocross bikes." Some 12-14 percent of off-highway motorcycles produced from 1996 to 2000 were motocross bikes. Other sources have estimated motocross bikes to be closer to 30 percent of off-highway sales.[91] Other types of competition motorcycles are the observed trials machines mentioned above, which emphasize handling ability rather than speed, and the so-called "enduro bikes." Enduro bikes are designed for cross-country type racing, rather than closed-course competition. As such, they require some of the equipment normally found on non-racing machines, such as spark arresters (required by U.S. Forest Service regulations) and at least minimal lighting packages.

Whether for competition or recreational use, off-highway motorcycles are operated under transient conditions that include a wide variety of speeds and load factors.

2.5.1.2 Engine Design and Operation

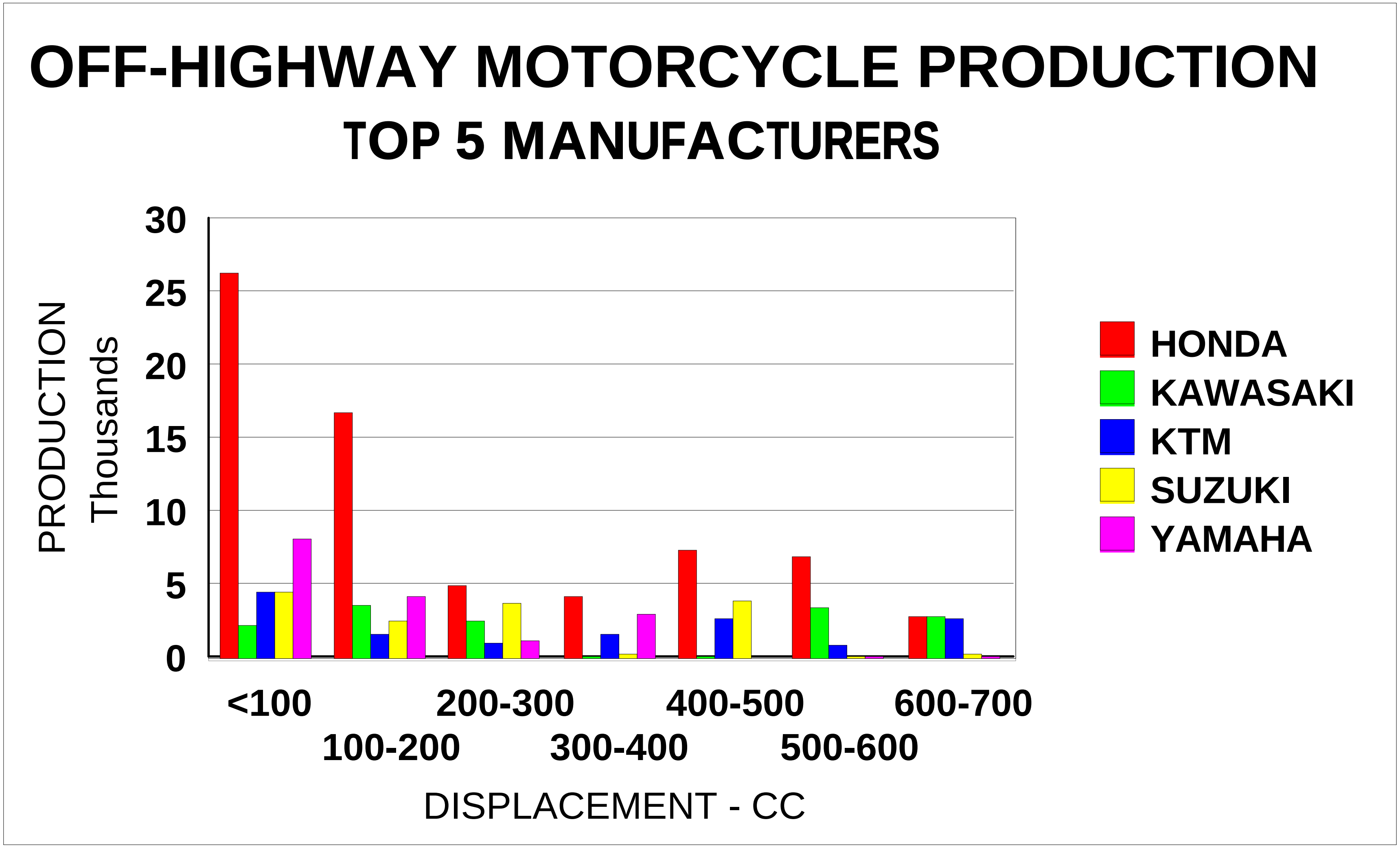
The off-road segment of the motorcycle market is dominated by vehicles with relatively small engines. Off-highway motorcycle engines have traditionally been about two-thirds smaller and less powerful than those used in on-highway cycles. In 1990 and 1998, approximately 88 percent of the off-highway motorcycles in use had an engine displacement less than 350cc. See Table 2.5-1.

Table 2.5-1
Quantities of Off-road Motorcycles By Engine Displacement
1990 and 1998 [92]

Engine Displacement	1990 Number of Motorcycles	1990 % of Total	1998 Number of Motorcycles	1998 % of Total
Under 125cc	306,000	40.8	367,200	30.7
125-349cc	346,500	46.2	680,500	56.9
350-499cc	30,000	4.0	34,700	2.9
450-749cc	67,500	9.0	113,600	9.5
Total	750,000	100	1,196,000	100

In the year 2000, about 68 percent of the models produced were less than 300cc displacement, and half of these were 100cc or less. Percentages by engine displacement for the top five producers are approximately the same as for the industry as a whole. The distribution of engine sizes for these producers tends to be somewhat skewed, with a larger fraction of off-highway motorcycles falling into the lower displacement ranges (see Figure 2.5-1). Unlike on-highway motorcycles, our contractor found no off-highway engines larger than 700cc are currently produced.

Figure 2.5-1 [93]



2.5.1.3 Two-Stroke vs Four-Stroke Cycle Engine Usage

Based on the PSR database, slightly more than half of the off-highway motorcycles produced for sale in the United States are powered by four-stroke cycle engines. However, estimates from the Motorcycle Industry Council (MIC) place the percentage of two-stroke sales at more than 60 percent. The percentage of two-strokes varies considerably by manufacturer. Honda, which accounts for more than 45 percent of this production, is predominantly a four-stroke manufacturer. Four-strokes comprise about two-thirds of its production. For Yamaha, the percentage is about 57 percent. The remainder of the foreign and domestic producers manufacture more two-stroke engines than four-strokes. For the other top-five producers, KTM, Kawasaki, and Suzuki, the percentage of two-stroke engines varies from 58 to 72 percent, and can be even higher (up to 100 percent) for some of the remaining manufacturers.

Two-stroke engines are normally used in two primary applications: (1) racing machines, because they tend to have a higher power-to-weight ratio than four-stroke engines (this is important for competition, especially in the smaller displacement classes), and (2) youth model or entry-level motorcycles, because two-strokes are cheaper to produce than four-strokes. Since youth or entry-level motorcycles also tend to have smaller displacement engines, the higher power-to-weight ratio of the two-stroke tends to provide slightly better performance. However, there has been a growing tendency in recent years for manufacturers to bring out more new four-stroke engines, particularly in the higher displacement ranges. This is also true in their competition lines.

2.5.1.4 Use of Engines in Other Applications

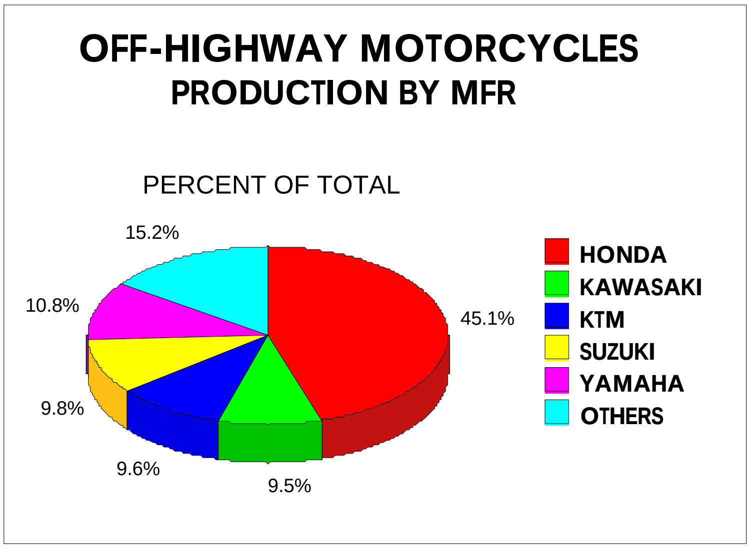
Only a few engine lines, primarily among the top five producers, are used in both off-highway and on-highway motorcycles. Part of the reason for this is because over half of the off-highway bikes use two-stroke engines, whereas almost no two-stroke engines are found in on-highway motorcycles. Also, as noted above, off-highway motorcycles generally have much smaller displacement engines than their on-highway counterparts. Off-highway motorcycle engines are closer in terms of engine size to ATV engines. However, ATVs also use predominantly four-stroke engines and these are not as likely to be highly-tuned for performance as are many off-highway motorcycle engines.

2.5.1.5 Off-Road Motorcycle Manufacturers

Motorcycle manufacturers are classified under the Standard Industrial Classification (SIC) code 3751 and under the North American Industry Classification System (NAICS) code 336991, Motorcycle, Bicycle and Parts Manufacturers. Motorcycle manufacturers have the subcode 3369913, which includes manufacturers of scooters, mopeds, and sidecars. To be classified as a small business by the Small Business Administration (SBA) size standards, the manufacturer must have fewer than 500 employees. Motorcycle importers are classified by subcode 4211101, which also includes automobile importers, and has an SBA size cutoff of 100 employees to be considered a small business.

Twenty five companies manufacture off-highway motorcycles. The five largest manufacturers, Honda, Kawasaki, Yamaha, Suzuki, and KTM. accounted for approximately 85 percent of all production sold in the U.S. in calendar year 2000. These companies manufacture automobiles and/or on-highway motorcycles, motorscooters, ATVs, Personal Water Crafts (PWC), as well as off-highway motorcycles. Honda is by far the largest producer of off-highway motorcycles, with over 45 percent of the total production for sale in the U.S. Figure 2.5-2 shows the market shares for the top five and the other producers, and Table 2.5-2 presents a list of the manufacturers of off-highway motorcycles.[94]

Figure 2.5-2



Source: ICF Consulting, Docket A-2000-01, Document II-A-84.

Of the 25 firms that manufacture off-highway motorcycles for the U.S. market, six are U.S. manufacturers. With the exception of Cannondale, which is primarily a bicycle manufacturer, all of these companies produce only motorcycles. Italy has five manufacturers. One of these, Cagiva, is mainly a producer of on-highway motorcycles. Piaggio is primarily a motorscooter manufacturer; Betamotor makes motorscooters and trials bikes. Lem and Polini manufacture youth motorcycles. Spanish manufacturers of off-highway motorcycles that are imported to the U.S. include Gas Gas Motos, primarily an observed trials bike manufacturer, and Montesa, which is owned by Honda. Other manufacturing companies whose products are imported into the U.S. market are also found in Austria, Belarus, Ireland, Korea, Sweden, Taiwan, and the United Kingdom. KTM, an Austrian company with a U.S. branch, is one of the five major producers for the U.S. market.

The 20 other manufacturers accounted for the remaining 15 percent of production for sale in the U.S. Six of these firms, accounting for approximately 3 percent of total production for the U.S. market, are located in this country. Dun and Bradstreet employee data are available for four of the six U.S. manufacturers, indicating that these are small businesses according to the SBA definition.

Our contractor has also identified 16 off-highway motorcycle importers. Eight of these are U.S.-owned. Dun and Bradstreet data are available for five of the eight U.S. importers, indicating that they are small businesses though it seems likely that all eight are small businesses.

Table 2.5-2
U.S. Off-Highway Motorcycle Manufacturers/Importers [95]

Firm Name	Type
ACTION POLINI	IMPORTER
BETA USA	IMPORTER
CODY RACING PRODUCTS	IMPORTER
COSMOPOLITAN MOTORS INC.	IMPORTER
CRE IMPORTS/E-LINE ACCESSORIES	IMPORTER
GAS GAS NORTH AMERICA	IMPORTER
HUSQVARNA USA	IMPORTER
KASEA MOTORSPORTS	IMPORTER
KTM SPORTMOTORCYCLE USA, INC.	IMPORTER
MIDWEST MOTOR VEHICLES, INC.	IMPORTER
TRANSNATIONAL OUTDOOR POWER, LLC	IMPORTER
TRYALS SHOP	IMPORTER
TWS-USA INC.	IMPORTER
U.S. MONTESA	IMPORTER
UNITED MOTORS OF AMERICA	IMPORTER
VOR MOTORCYCLES USA	IMPORTER
AMERICAN DIRT BIKE INC. (U.S.)	MANUFACTURER
ATK MOTORCYCLES (U.S.)	MANUFACTURER
BETAMOTOR SPA (ITALY)	MANUFACTURER
CAGIVA MOTORCYCLE SPA (ITALY)	MANUFACTURER
CANNONDALE CORP - BEDFORD (U.S.)	MANUFACTURER
CCM MOTORCYCLES LTD (U.K.)	MANUFACTURER
COBRA MOTORCYCLE MFG. (U.S.)	MANUFACTURER
GAS GAS MOTOS SPA (SPAIN)	MANUFACTURER
HM MOTORCYCLES (U.S.)	MANUFACTURER
HONDA MOTORCYCLES (JAPAN)	MANUFACTURER
HUSABERG MOTOR AB (SWEDEN)	MANUFACTURER
HYOSUNG MOTORS AND MACHINERY (KOREA)	MANUFACTURER

KAWASAKI HEAVY INDUSTRIES (JAPAN)	MANUFACTURER
KTM SPORT MOTORCYCLE AG (AUSTRIA)	MANUFACTURER
LEM MOTOR SAS (ITALY)	MANUFACTURER
MADFAST MOTORCYCLES (IRELAND)	MANUFACTURER
MINSK MOTOVELOZAVOD (BELARUS)	MANUFACTURER
MONTESA-HONDA ESPANA, SA (SPAIN)	MANUFACTURER
PIAGGIO GROUP (ITALY)	MANUFACTURER
POLINI (ITALY)	MANUFACTURER
REV! MOTORCYCLES (U.S.)	MANUFACTURER
SUZUKI (JAPAN)	MANUFACTURER
TAI LING MOTOR COMPANY LTD. (TAIWAN)	MANUFACTURER
VOR MOTORI (ITALY)	MANUFACTURER
YAMAHA MOTOR COMPANY LTD. (JAPAN)	MANUFACTURER

2.5.1.6 Engine Manufacturers

For the majority of off-highway motorcycles, the vehicle manufacturer is also the engine manufacturer. However, a few motorcycle manufacturers use engines produced by other firms. ATK Motorcycles and CCM Motorcycles Ltd. use Bombardier/Rotax engines, while the Tai Ling Motor Company uses Suzuki engines. The Spanish manufacturer, Gas Gas Motos, noted primarily for its observed trials machines, produces some of its own engines and buys others from Cagiva, a large Italian manufacturer. One U.S. manufacturer, Rokon, markets a low-production trail motorcycle resembling a large motorscooter. This vehicle type is intended for hunters and fishermen. Rokon uses industrial-type engines made by Honda and other manufacturers which are regulated under the EPA Small SI regulations. Therefore, Rokon is not included here.

As Table 2.5-3 shows the average value of shipments (VOS) for this industry over the 1992 to 1999 time period is equal to approximately 2.8 billion dollars, with the highest value of shipments occurring in 1998. The cost of materials for this industry is equal to an average of almost 1.6 billion dollars (57 percent of VOS). The average cost of labor is approximately 347 million (19 percent of VOS), while capital expenditures are equal to an average value of 26.7 million (1 percent of VOS). Examination of this data clearly shows that capital expenditures represent the smallest share of the value of shipments while the cost of materials represents the largest share.

Table 2.5-3
Value of Shipments (VOS) and Production Costs for the SIC and NAICS Codes that Include Off-Highway Motorcycle Manufacturers, 1992 - 1999 [96,97,98,99]

		VOS	Payroll		Cost of Materials		Total Capital Expenditures	
Year	Industry Code	($\$10^6$)	($\$10^6$)	% of VOS	($\$10^6$)	% of VOS	($\$10^6$)	% of VOS
1992	SIC 3751	1,878.9	301.7	16%	1,146.2	61%	10.6	1%
1993	SIC 3751	1,878.3	409.3	22%	1,362.0	73%	13.0	1%
1994	SIC 3537	2,632.1	482.6	18%	1,488.6	57%	14.2	1%
1995	SIC 3537	2,832.9	502.6	18%	1,541.6	54%	15.4	1%
1996	SIC 3537	3,094.0	565.1	18%	1,673.9	54%	17.9	1%
1997	NAICS 336991	3,382.6	662.3	20%	1,802.3	53%	19.5	1%
1998	NAICS 336991	3,343.8	620.3	19%	1,740.7	52%	9.6	0
1999	NAICS 336991	3,066.1	576.1	19%	1,611.3	53%	7.2	0
	Average	2,776.8	347.1	19%	1,559.1	57%	26.7	1%

* Value of Shipments, Payroll, Cost of Materials, and Total Capital Expenditures are in nominal U.S. dollars

2.5.2 The Demand Side

This section provides information on the uses of off-highway motorcycles, the various substitute products on the market, and the consumers who purchase off-highway motorcycles.

2.5.2.1 Uses of Off-Highway Motorcycles

Motorcycles are used for a for a variety of purposes, including recreation, touring, commuting, and on- and off-road racing. There are generally three motorcycle model types, on-highway, dual(both on highway and off-highway), and off-highway. On-highway motorcycles are certified by the manufacture as being in compliance with the Federal Motor Vehicle Safety Standards (FMVSS), and are designed for use on public roads. On-highway motorcycles include scooters, but excludes mopeds (limited speed motor-driven cycles under 50cc, with or without fully operative pedals). Dual motorcycles are certified by the manufacturer as being in compliance with FMVSS, and are designed with the capability for use on public roads, as well as off-highway recreational use. Off-highway motorcycles are not certified by the manufacturer to be in compliance with FMVSS for on-highway use. This category includes competition motorcycles. Table 2.5-4 show that off-highway motorcycles represents nearly 15% of the total population in 1998 and nearly 18% in 1998.

Table 2.5-4
Estimated Population By Model Type
1990 and 1998 [100]

MODEL TYPE	1990 NUMBER OF MOTORCYCLES	1998 NUMBER OF MOTORCYCLES
On-Highway	3,650,000 (72.3%)	4,809,000 (73%)
Dual	660,000 (13%)	565,000 (8.6%)
Off-Highway	750,000 (14.8%)	1,196,000 (18.2%)
Total	5,060,000 (100%)	6,570,000 (100%)

2.5.2.2 Substitution Possibilities

Consumers can substitute across off-road recreational vehicles. As a substitute, an ATV would allow the consumer to enjoy the same off-road recreation that they would receive with an off-highway motorcycle. Consumers may be interested in engaging in outdoor activities, but may instead consider doing a non-motorized activity. For example, consumers who are interested in being outside may engaging in hiking, running, or riding a bicycle. These non-motorized options will also allow the consumer to participate in outdoor activity, but they may be considered substitutes for less intensive off-highway past times. Indeed, any type of recreational activity may be viewed as a substitute for off-highway motorcycle usage.

2.5.3 Industry Organization

Because there are costs associated with the emission control program, it is important to determine how the off-highway motorcycle industry may be affected. Industry organization is an important factor which affects how an industry may react to regulatory costs. This section provides a description of the organization of the motorcycle industry.

2.5.3.1 Market Structure

Market structure is of interest because it determines the behavior of producers and consumers in the industry. In perfectly competitive industries, no producer or consumer is able to influence the price of the product sold. In addition, producers are unable to affect the price of inputs purchased for use in production. This condition is most likely to hold if the industry has a large number of buyers and sellers, the products sold and inputs used are homogeneous, and entry and exit of firms is unrestricted. Entry and exit of firms are unrestricted for most industries, except in cases where the government regulates who is able to produce output, where one firm holds a patent on a product, where one firm owns the entire stock of a critical input, or where a single firm is able to supply the entire market. In industries that are not perfectly competitive, producer and/or consumer behavior can have an effect on price.

Concentration ratios (CRs) and the Herfindahl-Hirschman index (HHI) can provide some insight into the competitiveness of an industry. The U.S. Department of Commerce reports these ratios and indices for the six digit NAICS code level for the year 1997, the most recent year available. Table 2.5-5 provides the four- and eight-firm concentration ratios (CR4 and CR8, respectively), and the Herfindahl-Hirschman index for the Motorcycle, Bicycle, and Parts Manufacturing industry, the industry that includes producers of off-highway motorcycles. This industry is represented by NAICS code 336991. For this industry the CR4 was 67.5 percent and the CR8 was 76.7 percent.

The criteria for evaluating the HHI are based on the 1992 Department of Justice Horizontal Merger Guidelines. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive). In general, firms in less concentrated industries have more ability to influence market prices. Though the HHI measure for this industry is high, we have chosen to model is as a perfectly competitive market. We have made this choice based on the number of recreational substitute available for off-highway motorcycles.

Table 2.5-5
Measures of Market Concentration for the
NAICS Code that Includes Off-Highway Motorcycle Manufacturers, 1997 [101]

Description	CR4	CR8	HHI	VOS ($\$10^6$)	Number of Companies
NAICS 336991	67.5	76.7	2,036.5	$3,382,689	373

2.5.3.2 Motorcycle Manufacturers

As mentioned above, motorcycles are included under Standard Industrial Classification (SIC) 3751. The U.S. motorcycle industry is relatively small compared to other industries such as the automobile industry. There are over 40 U.S. firms (Table 2.5-2) engaged in the manufacture and/or distribution of off-highway motorcycles. Six of these firms accounted for 90 percent of the new motorcycle units produced in the United States in 2000. Table 2.5-6 shows the ranking and market share for the major producers in the industry for 1999 and 2000.

Table 2.5-6
Motorcycle Manufacturers by Market Share 1999-2000 [102]

BRAND	1999 RANK	1999 MARKET SHARE	2000 RANK	2000 MARKET SHARE
Honda	2	24.1%	1	25.0%
Harley-Davidson	1	25.5%	2	23.0%
Yamaha	3	17.8%	3	19.3%
Suzuki	5	10.8%	4	11.2%
Kawasaki	4	11.8%	5	10.2%
BMW	6	1.9%	6	1.7%
All Others	--	8.1%	--	9.6%

In the off-highway segment, the top five manufacturers were Honda , Kawasaki, KTM, Suzuki, and Yamaha. Table 2.5-7 shows the market share among the major producers. U.S. off-highway motorcycle production by the top five firms steadily rose over the 1996 to 2000 time period, with a slight dip in 1999.

Table 2.5-7
Off-Highway Motorcycle Units Manufactured by the Top Five Firms 1996-1999 [103]

Company	1996	1997	1998	1999	2000	1996-2000 TOTAL	1996-2000 MARKET SHARE
Honda	45,694	51,281	56,678	53,706	68,924	276,283	48.0%
Suzuki	17,022	19,200	18,694	10,617	11,039	76,572	13.3%
Yamaha	23,862	29,231	25,230	26,079	20,406	124,808	21.7%
Kawasaki	12,687	12,147	13,249	12,885	14,560	66,528	11.5%
KTM	2,778	3,146	3,783	7,236	14,747	31,690	5.5%
Total	102,043	116,005	117,634	110,523	129, 676	575,881	100%

2.5.3.3 Small Businesses

The motorcycle companies listed in Table 2.5-2 can be grouped into small and large business categories using the Small Business Administration (SBA) general size standard definitions for NAICS codes. The SBA defines a small business in terms of the employment or annual sales of the owning entity and these thresholds vary by industry. Based on the size standard for NAICS 336991, several of the motorcycle producers are considered small businesses.

2.5.4 Markets

This section examines the historical market statistics for the off-highway motorcycle manufacturing industry. Historical data on the quantity of domestic shipments and price data of off-highway motorcycles are provided. The quantity and values of imports and exports for motorcycles are presented as well.

2.5.4.1 Quantity and Price Data

Historical market data on the quantity of U.S. unit sales of off-highway motorcycles are provided in Table 2.5-8. Data were obtained from the Motorcycle Industry Council (MIC). As this table shows, there has been an overall increasing trend in the quantity of off-highway motorcycles sold in the U.S. with an overall net increase of 290 percent and the retail value of off-highway motorcycle increased by nearly 40 percent from 1990 to 2000.

Table 2.5-8
U.S. Units Sold, Retail Dollars and
Retail Dollars Per Unit Off-Highway Motorcycles, 1990 - 2001 [104]

Year	Unit Sales	Retail Dollars	Retail Dollars/Unit
1990	39,221	$63,745,225	$1,625
1991	37,363	$63,670,177	$1,704
1992	39,345	$68,038,926	$1,729
1993	39,863	$75,033,960	$1,882
1994	40,991	$84,844,505	$2,070
1995	40,791	$94,125,405	$2,308
1996	45,266	$111,001,200	$2,452
1997	49,168	$119,041,853	$2,421
1998	59,930	$133,062,004	$2,220
1999	77,875	$170,303,959	$2,187
2000	120,501	$279,984,888	$2,324
2001	195,250	$334,983,201	$2,253

* Values are in nominal dollars.

2.5.4.2 Foreign Trade

Export and import values and quantities for off -highway motorcycle are presented in Table 2.2-9. These data show increasing trends for export and import values since 1989. Note these data reflect imports and exports for SIC 3751, motorcycles, bicycles, and parts.

Table 2.5-9
Import and Export Quantities and Values for Off-Highway Motorcycles, 1989 - 2001[105]

Year	Export Value (1,000 Dollars)	Export Quantity (1,000 Dollars)	Import Value (1,000 Dollars)	Import Quantity (1,000 Units)
1989	$244,722	$319	$1,325,309	32,829
1990	$419,911	$480	$1,216,239	37,164
1991	$615,439	$796	$1,370,364	40,850
1992	$671,331	$846	$1,574,380	37,823
1993	$702,831	$1,053	$1,758,664	42,767
1994	$711,053	$739	$1,800,564	40,322
1995	$850,229	$721	$2,178,559	43,937
1996	$906,040	$626	$2,046,358	41,868
1997	$976,494	$692	$2,117,154	48,622
1998	$918,277	$662	$2,445,434	45,565
1999	$738,152	$823	$2,993,162	43,008
2000	$798,357	$673	$3,898,859	37,846
2001	$967,947	$480	$3,895,486	26,592
Average	$732,368	$685	$2,201,579	39,938

* Values are in nominal dollars and reflect values for SIC 3751 Motorcycles, Bicycles, and Parts.

Chapter 2 References

1. "Recreational Boating Industry Characterization," ICF Consulting, Contract No. 68-C-98-170, WAN 0-5, August, 1999, Docket A-2000-01, Document II-A-9.

2. Boating Industry Magazine, "1997 Annual Industry Reviews: The Boating Business", January 1998. Docket A-2000-01, Document IV-A-116.

3. Dun & Bradstreet. 2001.

4. National Marine Manufacturers Association - http://www.nmma.org. Docket A-2000-01, Document IV-A-51.

5. National Marine Manufacturing Association. 2002. Economic Impact Analysis of the Diesel Engine Rule on the U.S. Boat Market. Docket A-2000-01, Document IV-A-53.

6. U.S. EPA. 1999. Economic Impact Analysis of the Proposed Boat Manufacturing NESHAP. Air Quality Strategies and Standards Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency. EPA-452/R-99-005. November.

7. U.S. Department of Commerce. 2001. *1999 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-58.

8. U.S. Department of Commerce. 2000. *1998 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-59.

9. U.S. Department of Commerce. 1999. *1997 Economic Census - Boat Building* Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-64.

10. U.S. Department of Commerce. 1998. *1996 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-65.

11. U.S. Department of Commerce. 1997. *1995 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-66.

12. U.S. Department of Commerce. 1996. *1994 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-67.

13. U.S. Department of Commerce. 1995. *1993 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-

2000-01, Document IV-A-68.

14. U.S. Department of Commerce. 2001. *1999 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-58.

15. U.S. Department of Commerce. 2000. *1998 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-59.

16. U.S. Department of Commerce. 1999. *1997 Economic Census - Other Engine Equipment Manufacturing*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-62.

17. U.S. Department of Commerce. 1998. *1996 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-65.

18. U.S. Department of Commerce. 1997. *1995 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-66.

19. U.S. Department of Commerce. 1996. *1994 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-67.

20. U.S. Department of Commerce. 1995. *1993 Annual Survey of Manufactures - Statistics for Industry Groups and Industries*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-68.

21. National Marine Manufacturing Association. Boating 2001 - Facts and Figures at a Glance. http://www.nmma.org/facts/boatingstats/2001/. Docket A-2000-01, Document IV-A-50.

22. National Marine Manufacturing Association. Boating 1998 - Facts and Figures at a Glance. http://63.236.237.146/facts/boatingstats/boating98.html.. Docket A-2000-01, Document IV-A-52.

23. U.S. Department of Commerce. 2001. *1997 Economic Census - Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-57.

24. U.S. Department of Commerce. 2001. *1997 Economic Census - Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-57.

25. Wards Business Directory. 2001.

26. Dun & Bradstreet. 2001.

27. American Business Directory. 2000.

28. Wards Business Directory. 2001.

29. Dun & Bradstreet. 2001.

30. American Business Directory. 2000.

31. National Marine Manufacturing Association. *U.S. Recreational Boating Domestic Shipment Statistics, 1970 - 1998*. http://63.236.237.146/facts/history.pdf.. Docket A-2000-01, Document IV-A-49.

32. National Marine Manufacturing Association. Boating 2001 - Facts and Figures at a Glance. http://www.nmma.org/facts/boatingstats/2001/. Docket A-2000-01, Document IV-A-50.

33. National Marine Manufacturing Association. *U.S. Recreational Boating Domestic Shipment Statistics, 1970 - 1998*. http://63.236.237.146/facts/history.pdf. Docket A-2000-01, Document IV-A-49.

34. National Marine Manufacturing Association. Boating 2001 - Facts and Figures at a Glance. http://www.nmma.org/facts/boatingstats/2001/. Docket A-2000-01, Document IV-A-50.

35. National Marine Manufacturing Association. *U.S. Recreational Boating Domestic Shipment Statistics, 1970 - 1998*. http://63.236.237.146/facts/history.pdf. Docket A-2000-01, Document IV-A-49.

36. National Marine Manufacturing Association. Boating 2001 - Facts and Figures at a Glance. http://www.nmma.org/facts/boatingstats/2001/. Docket A-2000-01, Document IV-A-50.

37. National Marine Manufacturing Association. Boating 2001 - Facts and Figures at a Glance. http://www.nmma.org/facts/boatingstats/2001/. Docket A-2000-01, Document IV-A-50.

38. National Marine Manufacturing Association. 2002. Economic Impact Analysis of the Diesel Engine Rule on the U.S. Boat Market. Table 4 - Product Analysis: Inboard Boats, Imports. Docket A-2000-01, Document IV-A-53.

39. National Marine Manufacturing Association. 2002. Supplemental Tables for Economic Impact Analysis of the Diesel Engine Rule on the U.S. Boat Market. Sterndrive Boats, Imports. Docket A-2000-01, Document IV-A-54.

40. National Marine Manufacturing Association. 2002. Economic Impact Analysis of the Diesel Engine Rule on the U.S. Boat Market. Table 4 - Product Analysis: Inboard Boats,

Exports. Docket A-2000-01, Document IV-A-53.

41. National Marine Manufacturing Association. 2002. Supplemental Tables for Economic Impact Analysis of the Diesel Engine Rule on the U.S. Boat Market. Sterndrive Boats, Exports. Docket A-2000-01, Document IV-A-54.

42. National Marine Manufacturing Association. 2002. Economic Impact Analysis of the Diesel Engine Rule on the U.S. Boat Market. Table 3 - Inboard Engines - Imports. Docket A-2000-01, Document IV-A-53.

43. National Marine Manufacturing Association. 2002. Supplemental Tables for Economic Impact Analysis of the Diesel Engine Rule on the U.S. Boat Market. Sterndrive Engines, Imports. Docket A-2000-01, Document IV-A-54.

44. National Marine Manufacturing Association. 2002. Economic Impact Analysis of the Diesel Engine Rule on the U.S. Boat Market. Table 3 - Inboard Engines - Imports. Docket A-2000-01, Document IV-A-53.

45. National Marine Manufacturing Association. 2002. Supplemental Tables for Economic Impact Analysis of the Diesel Engine Rule on the U.S. Boat Market. Sterndrive Engines, Exports. Docket A-2000-01, Document IV-A-54.

46."The Role of Propane in the Fork Lift/Industrial Truck Market: A Study of its Status, Threats, and Opportunities," Robert E. Myers for the National Propane Gas Association, December 1996, Docket A-98-01, Document II-D-2. Docket A-2000-01, Document II-A-86.

47. See footnote 46.

48. Industrial Truck Association. 2002. Membership Handbook. A copy of the relevant pages can be found in Docket A-2000-01, Document No. IV-A-188.

49. U.S. Department of Commerce. 2001. 1999 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-58.

50. U.S. Department of Commerce. 2000. 1998 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-59.

51. U.S. Department of Commerce. 1999. 1997 Economic Census - Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-63.

52. U.S. Department of Commerce. 1998. 1996 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-

01, Document IV-A-65.

53. U.S. Department of Commerce. 1997. 1995 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-66.

54. U.S. Department of Commerce. 1996. 1994 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-67.

55. U.S. Department of Commerce. 1995. 1993 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-68.

56. See footnote 46.

57. See footnote 48.

58. U.S. International Trade Commission. 1996. Industry and Trade Summary: Forklift Trucks and Related Vehicles. Washington, DC. Docket A-2000-01, Document IV-A-189

59. U.S Department of Commerce. 2001. 1997 Economic Census - Concentration Ratios in Manufacturing. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-57.

60. See footnote 48.

61. American Business Information. 2002. American Business Directory Electronic Database.

62. Dun & Bradstreet. 2002. Dun and Bradstreet Market Identifiers Electronic Database.

63. Ward's Business Directory, 53rd edition.

64. See footnote 48.

65. See footnote 13.

66. International Trade Commission. 2002. ITCDataWeb. Docket A-2000-01, Document IV-A-187.

67. International Snowmobile Association . www.snowmobile.org. June 2002. Docket A-2000-01, Document IV-A-128 and IV-A-136.

68. Production data were taken from OELINK Database owned by Power Systems Research.

69. Production data were taken from OELINK Database owned by Power Systems Research.

70. U.S. Department of Commerce. 2002. Statistics for Industry Groups and Industries: 2000. Annual Survey of Manufacturers Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-117.

71. U.S. Department of Commerce. 1998. 1996 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-65.

72. U.S. Department of Commerce. 1997. 1995 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-66.

73. U.S. Department of Commerce. 1996. 1994 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-67.

74. U.S. Department of Commerce. 1995. 1993 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-68.

75. Memo to Docket A-98-01 from Linc Wehrly, regarding Emission Modeling for Recreational Vehicles. Docket A-2000-01, Document II-B-19.

76. International Snowmobile Manufacturers Association. www.snowmobile.org. June. Docket A-2000-01, Documents IV-A-112 and Docket A-2000-01, Document IV-A-136.

77. US Department of Commerce. 1997 Economic Census - Concentration Ratio in Manufacturing. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-57.

78. USEPA. June 1998. "Regulatory Impact Analysis of Cement Kiln Dust Rulemaking." Final report prepared by Research Triangle Institute for Office of Air Quality Planning and Standards, RTP, North Carolina. See also USEPA. July 1996. "Economic Analysis of Air Pollution Regulations: Portland Cement." Final report prepared by Research Triangle Institute for Office of Air Quality Planning and Standards, RTP, North Carolina.

79. International Snowmobile Manufacturers Association. www.snowmobile.org. June 2002. Docket A-2000-01, Document IV-A-128 and IV-A-136.

80. International Snowmobile Manufacturers Association. www.snowmobile.org. June 2002. Docket A-2000-01, Document IV-A-128 and IV-A-136.

81. International Snowmobile Manufacturers Association. www.snowmobile.org. June 2002. Docket A-2000-01, Document IV-A-128 and IV-A-136.

82. ICF Consulting. 2001. Industry Characterization of Non-Road Recreational Vehicles, Draft Final Report. Prepared for U.S. Environmental Protection Agency, Office of Transportation and Air Quality, September 13, 2001. Docket A-2000-01, Document II-A-84.

83. U.S. Department of Commerce. 2002. Statistics for Industry Groups and Industries: 2000. Annual Survey of Manufacturers Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-117.

84. U.S. Department of Commerce. 1998. 1996 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-65.

85. U.S. Department of Commerce. 1997. 1995 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-66.

86. U.S. Department of Commerce. 1996. 1994 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-67.

87. U.S. Department of Commerce. 1995. 1993 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-68.

88. US Department of Commerce. 1997 Economic Census - Concentration Ratio in Manufacturing. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-57.

89. Motorcycle Industry Council, Inc. 2002. Docket A-2000-01, Document No. IV-A-138.

90. International Trade Commission. 2002. ITC Data Web. Docket A-2000-01, Document IV-A-193.

91. U.S. Environmental Protection Agency, Office of Transportation and Air Quality, 2001. Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines. Ann Arbor, MI. EPA 420-D-01-004. Docket A-2000-01, Document III-B-02 . This document is available on our website, www.epa.gov/otaq/regs/nonroad/proposal

92. ICF Consulting. 2001. Industry Characterization of Non-Road Recreational Vehicles, Draft Final Report. Prepared for U.S. Environmental Protection Agency, Office of Transportation and Air Quality, September 13, 2001. Docket A-2000-01, Document II-A-84.

93. ICF Consulting. 2001. Industry Characterization of Non-Road Recreational Vehicles, Draft Final Report. Prepared for U.S. Environmental Protection Agency, Office of Transportation and Air Quality, September 13, 2001. Docket A-2000-01, Document II-A-84.

94. ICF Consulting. 2001. Industry Characterization of Non-Road Recreational Vehicles, Draft Final Report. Prepared for U.S. Environmental Protection Agency, Office of Transportation and Air Quality, September 13, 2001. Docket A-2000-01, Document II-A-84.

95. ICF Consulting. 2001. Industry Characterization of Non-Road Recreational Vehicles, Draft Final Report. Prepared for U.S. Environmental Protection Agency, Office of Transportation and Air Quality, September 13, 2001. Docket A-2000-01, Document II-A-84.

96.U.S. Department of Commerce. 1998. 1996 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-65.

97.U.S. Department of Commerce. 1997. 1995 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-66.

98.U.S. Department of Commerce. 1996. 1994 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-67.

99.U.S. Department of Commerce. 1995. 1993 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-68.

100.See footnote 90.

101.US Department of Commerce. 1997 Economic Census - Concentration Ratio in Manufacturing. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-57.

102.See footnote 90.

103.See footnote 90.

104. Motorcycle Industry Council, Inc. 2002. Docket A-2000-01, Document No. IV-A-138.

105.International Trade Commission. 2002. ITC Data Web. Docket A-2000-01, Document IV-A-193.

Chapter 3: Technology

This chapter describes the current state of spark-ignition technology for engines, evaporative emission technology, and compression-ignition technology for marine engines, as well as the emission control technologies expected to be available for manufacturers. Chapter 4 presents the technical analysis of the feasibility of the standards.

3.1 Introduction to Spark-Ignition Engine Technology

The two most common types of engines are gasoline-fueled engines and diesel-fueled engines. These engines have very different combustion mechanisms. Gasoline-fueled engines initiate combustion using spark plugs, while diesel fueled engines initiate combustion by compressing the fuel and air to high pressures. Thus these two types of engines are often more generally referred to as "spark-ignition" and "compression-ignition" (or SI and CI) engines, and include similar engines that used other fuels. SI engines include engines fueled with liquefied petroleum gas (LPG) and compressed natural gas (CNG).

3.1.1 Four-Stroke Engines

Four-stroke engines are used in many different applications. Virtually all automobiles and many trucks are powered by four-stroke SI engines. Four-stroke engines are also very common in motorcycles, all-terrain vehicles (ATVs), boats, airplanes, and numerous nonroad applications such as lawn mowers, lawn and garden tractors, and generators, to name just a few.

A “four-stroke” engine gets it’s name from the fact that the piston makes four passes or strokes in the cylinder to complete an entire cycle. The strokes are intake, compression, power, and exhaust. Two of the strokes are downward (intake & power) and two of the strokes are upward (compression & exhaust). Valves in the combustion chamber open and close to route gases into and out of the combustion chamber or create compression.

The first step of the cycle is for an intake valve in the combustion chamber to open during the “intake” stroke allowing a mixture of air and fuel to be drawn into the cylinder while an exhaust valve is closed and the piston moves down the cylinder.   The piston moves from top dead center (TDC) or the highest piston position to bottom dead center (BDC) or lowest piston position. This creates a vacuum or suction in the cylinder, which draws air and fuel past the open intake valve into the combustion chamber.

The intake valve then closes and the momentum of the crankshaft causes the piston to move back up the cylinder from BDC to TDC, compressing the air and fuel mixture. This is the “compression” stroke. As the piston nears TDC, at the very end of the compression stroke, the air and fuel mixture is ignited by a spark from a spark plug and begins to burn. As the air and fuel mixture burns, increasing temperature and pressure cause the piston to move back down the cylinder, transmitting power to the crankshaft. This is referred to as the “power” stroke. The last stroke in the four-stroke cycle is the “exhaust” stroke. At the bottom of the power stroke, an exhaust valve opens in the combustion chamber and as the piston moves back up the cylinder, the burnt gases are pushed out through the exhaust valve to the exhaust manifold, and the cycle is complete.

3.1.2 Two-Stroke Engines

Two-stroke SI engines are widely used in nonroad applications, especially for recreational vehicles, such as snowmobiles, off-highway motorcycles and ATVs. The basic operating principle of the charge scavenged two-stroke engine (traditional two-stroke) is well understood; in two-strokes the engine performs the operations of intake, compression, expansion and exhaust, which the four-stroke engine requires four strokes to accomplish. Two-stroke engines have several advantages over traditional four-stroke engines for use in recreational vehicles: high power-to-weight ratios; simplicity; ease of starting; and lower manufacturing costs. However, they also have much higher emission rates.

Another difference between two- and four-stroke engines is how the engines are lubricated. Four-stroke engines use the crankcase as a sump for lubricating oil. Oil is distributed throughout the engine by a pump through a series of small channels. Because the crankcase in a two-stroke engine serves as the pump for the scavenging process, it is not possible to use it as an oil sump as is the case for four-stroke engines. Otherwise, gasoline would mix with the oil and dilute it. Instead, lubrication for two-stroke engines is provided by mixing specially-formulated two-stroke oil with the incoming charge of air and fuel mixture. The oil is either mixed with the gasoline in the fuel tank, or metered into the gasoline as it is consumed, using a small metering pump. As the gasoline/oil mixture passes through the carburetor, it is atomized into fine droplets and mixed with air. The gasoline quickly vaporizes, while the less volatile oil forms a fine mist of fine droplets. Some of these droplets contact the crankshaft, piston pin, and cylinder walls, providing lubrication. Most of the oil droplets, however, pass out of the crankcase and into the cylinder with the rest of the incoming charge.

In a two-stroke engine, combustion occurs in every revolution of the crankshaft. Two-stroke engines eliminate the intake and exhaust strokes, leaving only compression and power strokes. This is due to the fact that two-stroke engines do not use intake and exhaust valves. Instead, they have openings, referred to as “ports,” in the sides of the cylinder walls. There are typically three ports in the cylinder; an intake port that brings the air-fuel mixture into the crankcase; a transfer port that channels the air and fuel mixture from the crankcase to the combustion chamber; and an exhaust port that allows burned gases to leave the cylinder and flow into the exhaust manifold. Two-stroke engines route incoming air and fuel mixture first into the crankcase, then into the cylinder via the transfer port. This is fundamentally different from a four-stroke engine which delivers the air and fuel mixture directly to the combustion chamber.

With a two-stroke engine, as the piston approaches the bottom of the power stroke, it uncovers exhaust ports in the wall of the cylinder. The high pressure burned combustion gases blow into the exhaust manifold. At the same time, downward piston movement compresses the fresh air and fuel mixture charge in the crankcase. As the piston gets closer to the bottom of the power stroke, the transfer ports are uncovered, and fresh mixture of air and fuel are forced into the cylinder while the exhaust ports are still open. Exhaust gas is "scavenged" or forced into the exhaust by the pressure of the incoming charge of fresh air and fuel. In the process, however, some mixing between the exhaust gas and the fresh charge of air and fuel takes place, so that some of the fresh charge is also emitted in the exhaust. Losing part of the fuel out of the exhaust during scavenging causes the very high hydrocarbon emission characteristics of two-stroke engines.

At this point, the power, exhaust, and transfer events have been completed. When the piston begins to move up, its bottom edge uncovers the intake port. Vacuum draws fresh air and fuel into the crankcase. As the piston continues upward, the transfer port and exhaust ports are closed. Compression begins as soon as the exhaust port is blocked. When the piston nears TDC, the spark plug fires and the cycle begins again.

3.1.3 - Engine Calibration

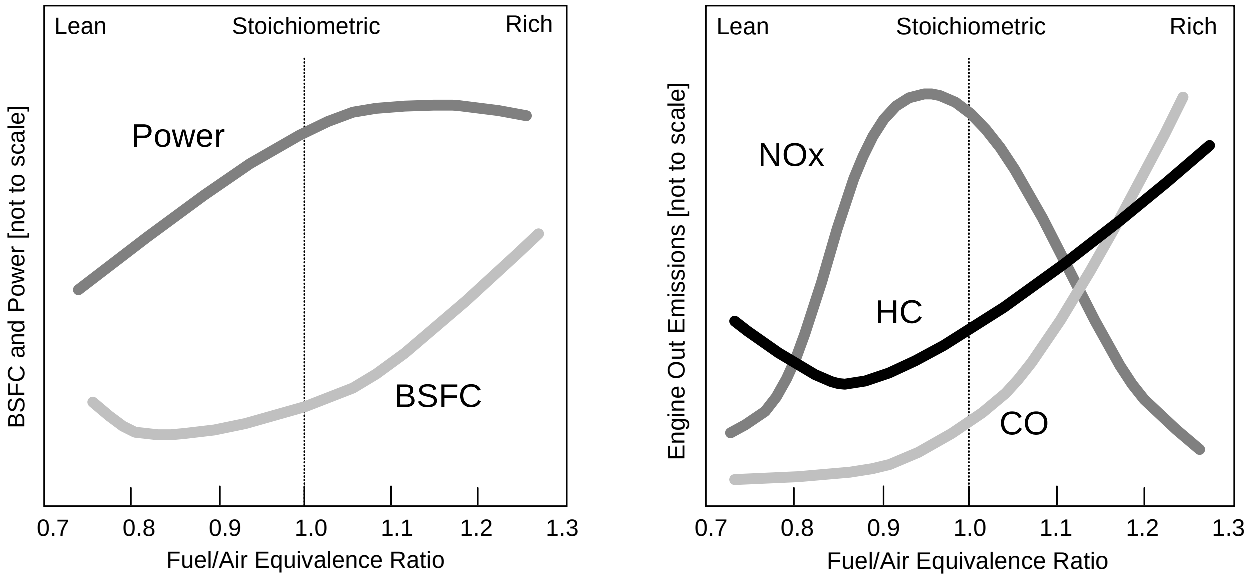
For most current SI engines, the two primary variables that manufacturers can control to reduce emissions are the air and fuel mixture (henceforth referred to as air-fuel ratio) and the spark timing. For highway motorcycles, these two variables are the most common methods for controlling exhaust emissions. However, for many nonroad engines and vehicles, the absence of emission standards have resulted in air-fuel ratio and spark timing calibrations optimized for engine performance and durability rather than for low emissions.

3.1.3.1 Air-fuel ratio

The calibration of the air-fuel mixture affects power, fuel consumption (referred to as Brake Specific Fuel Consumption (BSFC)), and emissions for SI engines. The effects of changing the air-fuel mixture are shown in Figure 3.1-1.[1] Traditionally, in most nonroad SI applications, manufacturers have calibrated their fuel systems for rich operation for two main advantages. First, by running the engine rich, manufacturers can reduce the risk of lean misfire due to imperfect mixing of the fuel and air and variations in the air-fuel mixture from cylinder to cylinder. Second, by making extra fuel available for combustion, it is possible to get more power from the engine. At the same time, since a rich mixture lacks sufficient oxygen for full combustion, it results in increased fuel consumption rates and higher HC and CO emissions. As can be seen from the figure, the best fuel consumption rates occur when the engine is running lean.

With the use of more advanced fuel systems, manufacturers would be able to improve control of the air-fuel mixture in the cylinder. This improved control allows for leaner operation without increasing the risk of lean misfire. This reduces HC and CO emissions and fuel consumption. Leaner air-fuel mixtures, however, increase NOx emissions due to the higher temperatures and increased supply of oxygen.

Figure 3.1-1: Effects of Air-fuel Ratio on Power, Fuel Consumption, and Emissions



3.1.3.2 Spark-timing:

For each engine speed and air-fuel mixture, there is an optimum spark-timing that results in peak torque. If the spark is advanced to an earlier point in the cycle, more combustion occurs during the compression stroke. If the spark is retarded to a later point in the cycle, peak cylinder pressure is decreased because too much combustion occurs later in the expansion stroke when it generates little torque on the crankshaft. Timing retard may be used as a strategy for reducing NOx emissions, because it suppresses peak cylinder temperatures that lead to high NOx levels. Timing retard also results in higher exhaust gas temperatures, because less mechanical work is extracted from the available energy. This may have the benefit of warming catalyst material to more quickly reach the temperatures needed to operate effectively during light-load operation.[2] Some automotive engine designs rely on timing retard at start-up to reduce cold-start emissions.

Advancing the spark-timing at higher speeds gives the fuel more time to burn. Retarding the spark timing at lower speeds and loads avoids misfire. With a mechanically controlled engine, a fly-weight or manifold vacuum system adjusts the timing. Mechanical controls, however, limit the manufacturer to a single timing curve when calibrating the engine. This means that the timing is not completely optimized for most modes of operation.

3.1.3.3 - Fuel Metering

Fuel injection has proven to be an effective and durable strategy for controlling emissions and reducing fuel consumption from highway gasoline engines. Comparable upgrades are also available for gaseous fuels. This section describes a variety of technologies available to improve fuel metering.

Throttle-body gasoline injection: A throttle-body system uses the same intake manifold as a carbureted engine. However, the throttle body replaces the carburetor. By injecting the fuel into the intake air stream, the fuel is better atomized than if it were drawn through with a venturi. This results in better mixing and more efficient combustion. In addition, the fuel can be more precisely metered to achieve benefits for fuel economy, performance, and emission control.

Throttle-body designs have the drawback of potentially large cylinder-to-cylinder variations. Like a carburetor, TBI injects the fuel into the intake air at a single location upstream of all the cylinders. Because the air-fuel mixture travels different routes to each cylinder, the amount of fuel that reaches each cylinder will vary. Manufacturers account for this variation in their design and may make compromises such as injecting extra fuel to ensure that the cylinder with the leanest mixture will not misfire. These compromises affect emissions and fuel consumption.

Multi-port gasoline injection: As the name suggests, multi-port fuel injection means that a fuel injector is placed at each of the intake ports. A quantity of fuel is injected each time the intake valve opens for each cylinder. This allows manufacturers to more precisely control the amount of fuel injected for each combustion event. This control increases the manufacturer’s ability to optimize the air-fuel ratio for emissions, performance, and fuel consumption. Because of these benefits, multi-port injection is has been widely used in automotive applications for over 15 years.

Sequential injection has further improved these systems by more carefully timing the injection event with the intake valve opening. This improves fuel atomization and air-fuel mixing, which further improves performance and control of emissions.

A newer development to improve injector performance is air-assisted fuel injection. By injecting high pressure air along with the fuel spray, greater atomization of the fuel droplets can occur. Air-assisted fuel injection is especially helpful in improving engine performance and reducing emissions at low engine speeds. In addition, industry studies have shown that the short burst of additional fuel needed for responsive, smooth transient maneuvers can be reduced significantly with air-assisted fuel injection due to a decrease in wall wetting in the intake manifold. On a highway 3.8-liter engine with sequential fuel injection, the air assist was shown to reduce HC emissions by 27 percent during cold-start operating conditions. At wide-open-throttle with an air-fuel ratio of 17, the HC reduction was 43 percent when compared with a standard injector.[3]

3.1.4 - Alternate Fuels

Gaseous-fuel engines

Engines operating on LPG or natural gas carry compressed fuel that is gaseous at atmospheric pressure. The technical challenges for gasoline related to an extended time to vaporize the fuel don't apply to gaseous-fuel engines. Typically, a mixer introduces the fuel into the intake system. Manufacturers are pursuing new designs to inject the fuel directly into the intake manifold. This improves control of the air-fuel ratio and the combustion event, similar to the improvements in gasoline injection technology.

3.2 - Exhaust Emissions and Control Technologies

3.2.1 - Current Two-Stroke Engines

As discussed above, two-stroke engines are typically found in applications where light weight, low cost, simplistic design, easy starting, and high power-to-weight ratio are desirable attributes. Of the engines and vehicles and covered by this rulemaking, the engines found in recreational vehicles tend to have a high percentage of two-stroke engines. For example, almost all snowmobiles use two-stroke engines, while 40 percent of off-highway motorcycles are equipped with two-strokes. Approximately 20 percent of all ATVs use two-stroke engines.

California ARB has had exhaust emission standards for off-highway motorcycles and ATVs since 1996. However, the regulations allow the sales and use of non-certified vehicles within the state. Thus, recreational vehicles equipped with two-stroke engines have essentially been unregulated. As a result, two-stroke engines used in recreational vehicles are typically designed for optimized performance and durability rather than low emissions. Current two-stroke engines emit extremely high levels of HC and CO emissions. The scavenging of unburned fuel into the exhaust contributes to the bulk of the HC emissions. Up to 30 percent[j] of the air and fuel mixture (along with lubricating oil) can pass unburned from the combustion chamber to the exhaust, resulting not only in high levels of HC, but also in high levels of particulate matter (PM). As discussed above, two-stroke engines lubricate the engine by mixing specially-formulated two-stroke oil with gasoline. As the gasoline/oil mixture passes through the carburetor, it is atomized into fine droplets and mixed with air. The gasoline quickly vaporizes, while the less volatile oil forms a fine mist of fine droplets. Some of these droplets contact the crankshaft, piston pin, and cylinder walls, providing lubrication. Most of the oil droplets, however, pass out of the crankcase and into the cylinder with the rest of the incoming charge. Much of this oil mist will be trapped in the cylinder and burned along with the gasoline vapor. Since lubricating oil is less combustible than gasoline, some of the oil will survive the combustion process in the cylinder and be passed into the exhaust. In the hot exhaust, the oil may vaporize, however, as the exhaust cools and through mixing with air after it is emitted, the oil vapor recondenses into very fine droplets or particles and enter the atmosphere as PM.

[j] Hare et al, 1974; Batoni, 1978; Nuti and Martorano, 1985

Another major source of unburned HC emissions from two-stroke engines is due to misfire or partial combustion at light loads. Under light load conditions such as idle, the flow of fresh air and fuel into the cylinder is reduced, and substantial amounts of exhaust gas are retained in the cylinder. This high fraction of residual gas leads to incomplete combustion or misfire, which is the source of the “popping” sound produced by two-stroke engines at idle and light loads. These unstable combustion events are major sources of unburned HC at idle and light load conditions.[k]

High CO levels from two-stroke engines are a result of operating the engine at rich air and fuel mixture levels to promote engine cooling and enhance performance. Two-stroke engines typically have very low levels of NOx emissions due to relatively cool combustion temperatures. Two-stroke engines have cooler combustion temperatures as a result of two phenomenon: rich air and fuel mixture operation and internal exhaust gas recirculation. Two-stroke engines tend to operate with a rich air and fuel mixture to increase power and to help cool the engine. Because many two-stroke engines are air-cooled, the extra cooling provided by operating rich is a desirable engine control strategy. Combustion with a rich air and fuel mixture results in some incomplete combustion which means less efficient combustion and a lower combustion temperature. High combustion temperature is the main variable in producing NOx emissions. Two-stroke engines also tend to have a high levels of naturally occurring exhaust gas recirculation due to the scavenging process where some of the burned gases are drawn back into the cylinder rather than being emitted out into the exhaust. The addition of burned exhaust gas into the fresh charge of air and fuel mixture in the combustion chamber also results in less complete or efficient combustion, which lowers combustion temperatures and reduces NOx emissions.

HC emissions for recreational vehicle two-stroke engines are approximately 25 times higher than for recreational vehicle four-stroke emissions. CO levels are roughly the same for both types of engines, while NOx levels are 1.5 times lower than four-stroke engine levels. Table 3.2-1 shows two-stroke emission results for several off-highway motorcycles and ATVs tested by and for EPA in grams per kilometer (g/km). Table 3.2-2 shows two-stroke emission results from snowmobiles in grams per horsepower-hour (g/hp-hr).

[k] Tsuchiya et al, 1983; Abraham and Prakash, 1992; Aoyama et al, 1977

Table 3.2-1
Baseline Two-Stroke Emissions From Off-Highway Motorcycles & ATVs (g/km)

MC or ATV	Manufacturer	Model	Model Year	Eng. Displ.	HC	CO	NOx
ATV	Suzuki	LT80	1998	80 cc	7.66	24.23	0.047
ATV	Polaris	Scrambler 80	2001	90 cc	38.12	25.08	0.057
ATV	Polaris	Trailblazer	2000	250 cc	18.91	44.71	0.040
MC	KTM	125SX	2001	125 cc	33.71	31.01	0.008
MC	KTM	125SX	2001	125 cc	61.41	32.43	0.011
MC	KTM	200EXC	2001	200 cc	53.09	39.89	0.025
MC	Honda	n/a	1993	200 cc	8.00	16.00	0.010
MC	Honda	n/a	1993	200 cc	26.00	28.00	1.010
MC	Honda	n/a	1995	249 cc	12.00	21.00	0.010
MC	Honda	CR250R	1997	249 cc	17.47	36.62	0.004
MC	Honda	n/a	1998	249 cc	23.00	36.00	0.010
MC	KTM	250SX	2001	249 cc	62.89	49.29	0.011
MC	KTM	250EXC	2001	249 cc	59.13	40.54	0.016
MC	KTM	300EXC	2001	298 cc	47.39	45.29	0.0124
Average					33.56	33.51	0.091

Table 3.2-2
Baseline Two-Stroke Emissions From Snowmobiles (g/hp-hr)

Source	Eng. Displ.	HC	CO	NOx	PM
Carroll 1999 (SwRI) YNP	480 cc	115	375	0.69	0.7
White et al. 1997	488 cc	150	420	0.42	1.1
White et al. 1997	440 cc	160	370	0.50	3.4
Hare & Springer 1974	436 cc	89	142	1.40	6.1
Hare & Springer 1974	335 cc	120	235	1.80	2.5
Hare & Springer 1974	247 cc	200	63	3.40	2.6
Wright & White 1998	440 cc	130	380	0.42	n/a
Wright & White 1998	503 cc	105	400	0.73	n/a
ISMA #1	600 cc	110	218	0.86	n/a
ISMA #2	440 cc	95	312	1.62	n/a
ISMA #3	600 cc	106	196	1.30	n/a
ISMA #4	900 cc	95	215	0.84	n/a
ISMA #5	698 cc	92	298	0.34	n/a
ISMA #6	597 cc	100	328	0.30	n/a
ISMA #7	695 cc	88	345	0.24	n/a
ISMA #8	485 cc	148	385	0.56	n/a
ISMA #9	340 cc	104	297	0.84	n/a
ISMA #10	440 cc	95	294	0.56	n/a
ISMA #11	600 cc	94	262	0.81	n/a
ISMA #12	700 cc	102	355	0.69	n/a
ISMA #13	593 cc	67	288	0.57	n/a
ISMA #14	494 cc	105	400	0.43	n/a
ISMA #15	699 cc	92	276	0.50	n/a
Average		111	298	0.86	2.7

3.2.2 - Clean Two-Stroke Technologies

Technologies available for reducing two-stroke emissions can be grouped into several categories: calibration improvements; combustion chamber modifications; improved scavenging characteristics; advanced fuel metering systems; and exhaust aftertreatment technologies.

3.2.2.1 - Calibration Improvements

The vast majority of two-stroke engines used in recreational vehicles use a carburetor as the means of metering the air and fuel that is supplied to the engine. The carburetion system supplies a controlled mixture of air and fuel to the engine, taking into consideration engine temperature and load and speed, while trying to optimize engine performance and fuel economy. A carburetor is a mechanical fuel atomizing device. It uses the venturi or Bernoulli's principle, which is based on pressure differences, to draw fuel into the air stream from a small reservoir (known as the "bowl"). A venturi is a restriction formed in the carburetor throat. As air passes through the venturi, it causes an increase in air velocity and creates a vacuum or low pressure. The fuel in the bowl is under atmospheric pressure. The higher pressure fuel will flow to the lower pressure (vacuum) created in the airstream by the venturi. The fuel is atomized (broken into small droplets) as it enters the airstream.

As discussed above in section 3.1.3.1, the calibration of the air-fuel mixture affects power, fuel consumption, and emissions. Traditionally, in most recreational vehicles using two-stroke engines, manufacturers have calibrated their fuel systems for rich operation for two main advantages. First, by running the engine rich, manufacturers can reduce the risk of lean misfire due to imperfect mixing of the fuel and air and variations in the air-fuel mixture from cylinder to cylinder. Second, by making extra fuel available for combustion, it is possible to get more power from the engine. At the same time, since a rich mixture lacks sufficient oxygen for full combustion, it results in increased fuel consumption rates and higher HC and CO emissions.

One means of reducing HC and CO emissions from two-stroke engines is to calibrate the air-fuel ratio for lower emissions. This means leaning the air-fuel mixture, so that there is more oxygen available to oxidize HC and CO. This strategy appears simplistic, but the manufacturer has to not only optimize the air-fuel ratio for emissions, but also allow acceptable performance and engine cooling. This means that the air-fuel ratio must not be leaned to the point of causing lean misfire or substantially reduced power. However, since it is common for manufacturers to set-up their carburetors to operate overly rich, there is opportunity for better optimization of carburetor air-fuel settings to account for performance, engine cooling and lower emissions.

3.2.2.2 - Combustion Chamber Modifications

For two-stroke engines, if modifications are made to air-fuel calibrations that result in leaner operation, one of the main concerns is that the combustion temperature will increase and result in engine damage. It is fairly common for two-stroke engines to seize the piston in the cylinder if they operate at too high of combustion temperatures. Piston seizure results when combustion chamber temperatures become excessive and the piston heats-up and expands until it becomes lodged or seizes in the cylinder. Depending on the level of enleanment used to control HC and CO emissions, it may be necessary to also incorporate modifications to the combustion chamber. Combustion chamber and piston configuration can be improved to induce more swirl and squish or turbulent motions during the compression stroke, as well as control the flow direction of the air and fuel mixture as it enters the combustion chamber to minimize short-circuiting (unburned fuel leaving thru the exhaust port). Increasing turbulence in the combustion chamber improves thermal efficiency by increasing the rate of burning in the chamber, which results in lower combustion temperatures. Improved combustion chamber and piston configurations can also minimize the formation of pocket or dead zones in the cylinder volume where unburned gases can become trapped. Many engine designs induce turbulence into the combustion chamber by increasing the velocity of the incoming air-fuel mixture and having it enter the chamber in a swirling motion (known as “swirl”).

3.2.2.3 - Improved Scavenging Characteristics

As discussed above, the exhaust and intake events for two-stroke engines overlap extensively, resulting in considerable amounts of unburned gasoline and lubricating oil passing through the engine and out the exhaust into the atmosphere. As the piston moves downward uncovering the exhaust port, a fresh charge of air and fuel enters the combustion chamber under pressure from the transfer port and pushes the burned gases from the previous combustion event out into the exhaust. Since the burned gases are pushed out of the chamber by the intake mixture, some of the fresh air and fuel mixture being introduced into the chamber are also lost through the exhaust port. The ideal situation would be to retain all of the fresh charge in the cylinder while exhausting all of the burned gases from the last cycle. This is difficult in most current two-stroke engine designs, since the cylinder ports and piston timing are generally designed for high scavenging efficiency, in order to achieve maximum power and a smoother idle, which results in higher scavenging losses and emissions. It is possible to reconfigure the cylinder ports to fine tune the scavenging characteristics for lower emissions, but this involves significant trade-offs with engine performance. There are, however, several techniques that can be employed to improve scavenging losses.

Exhaust charge control technology modifies the exhaust flow by introducing one-way control valves in the exhaust, or by making use of the exhaust pressure pulse wave. In order to get increased power out of a two-stroke engine, it is imperative that the engine combust as much air and fuel as possible. Scavenging losses from two-stroke engines (called “short-circuiting”) allow a large percentage of the air and fuel to leave the combustion chamber before they can be combusted. Two-stroke engines used in recreational vehicles all tend to use an exhaust system equipped with an “expansion chamber.” An expansion chamber is typically made of two cones, one diverging and the other converging, with a short straight section of pipe between the two cones. As the exhaust pulse leaves the exhaust port and enters the exhaust pipe, it travels through the diverging cone and expands. The expanded pulse travels through the straight section of pipe and then meets the converging cone. Upon hitting the converging cone, the exhaust pulse wave becomes a sonic wave and travels back into the combustion chamber, pushing some of the burnt exhaust gases and fresh charge of air and fuel that escaped originally.

As part of the Society of Automotive Engineers (SAE) Clean Snowmobile Challenge 2001, a college competition which encourages the development clean snowmobile technologies, Colorado State University (CSU) developed a two-stroke snowmobile engine using a supercharged “reverse uniflow” design. The reverse uniflow design incorporates an exhaust port and a crankcase pressure activated intake valve. After the ignition of the charge occurs at TDC, the high combustion pressures and expanding gases force the piston downward. As the bottom of the piston covers the exhaust port, the pressure in the crankcase increases due to a decreasing volume. The increasing pressure is transmitted to the check-valve diaphragm. As the piston fully uncovers the exhaust port, the exhaust gases are expelled out of the port, and the cylinder pressure goes to approximately atmospheric pressure. Due to the larger pressure in the crankcase (and thus on the diaphragm) as compared to the cylinder, the check-valve opens and the supercharged intake begins to runs into the cylinder. As the intake air is entering the cylinder, expelling the exhaust gases out of the bottom ports, a fuel injector or carburetor provides fuel into the intake air stream. After the piston reaches BDC, and begins to move back upwards, the crankcase pressure decreases. Once the piston moves past the exhaust port, the crankcase pressure returns to approximately atmospheric pressure, and the check-valve completely closes. The piston continues up, compressing the air-fuel mixture until the point that ignition can once again occur, completing the cycle.

3.2.2.4 - Advanced Fuel Metering Systems

The most promising technology for reducing emissions from two-stroke engines are advanced fuel metering systems, otherwise known as fuel injection systems. For two-stroke engines, there are two types of fuel injection systems available. The first system is electronic fuel injection (EFI), similar to what exists on automobiles. This system consists of an electronic fuel injector, an electronic fuel pump, pressurized fuel lines and an electronic control unit (ECU) or computer. EFI also requires the use of various sensors to provide information to the ECU so that precise fuel control can be delivered. These sensors typically monitor temperature, throttle position and atmospheric pressure. The use of EFI can provide better atomization of the fuel and more precise fuel delivery than found with carburetors, which can reduce emissions. EFI systems also have the advantage of providing improved power and fuel economy, when compared to a carburetor. However, EFI does not address the high emission resulting from short-circuiting or scavenging losses.

The second type of fuel injection system, known as Direct Injection (DI), does address scavenging losses. DI systems are very similar to EFI systems, since both are electronically controlled systems. The main difference is that DI systems more fully atomize (i.e., break-down into very small droplets) the fuel, which can greatly improve combustion efficiency resulting in improved power and reduced emissions. DI engines pump only air into the cylinder, rather than air and fuel. Finely atomized fuel is then injected into the combustion chamber once all of the ports are closed. This eliminates the short-circuiting of fresh air and fuel into the exhaust port. The biggest problem with DI is that there is very little time for air to be pumped into the cylinder and fuel then injected after all of the ports have closed. This is overcome by the use of numerous engines sensors, a high-speed electronic control module, and software which uses sophisticated control algorithms.

DI systems have been in use for the past several years in some small motorcycle, scooter and marine applications, primarily for personal watercraft (PWC) and outboard engines. There are numerous variations of DI systems, but two primary approaches that are commercially available today: high pressure injection and air-assisted injection. There are a number of companies who have developed high pressure DI systems, but the most successful systems currently belong to FICHT and Yamaha. The FICHT system uses a special fuel injector that is able to inject fuel at very high pressure (e.g., over 250 psi). The fuel injector itself is essentially a piston that is operated by an electromagnet. Fuel enters the injector at low pressure from an electric fuel pump and is forced out of the injector nozzle at high pressure when the piston hammers down on the fuel. The Yamaha system uses a high pressure fuel pump to generate the high fuel pressure. The other DI approach that is most common in various engine applications is the air-assisted injection system which has been developed by Orbital. The Orbital system uses pressurized air to help inject the fuel into the combustion chamber. The system uses a small single cylinder reciprocating air compressor to assist in the injection of the fuel. All three systems are currently used in some marine applications by companies such as Kawasaki, Polaris, Sea-Doo, and Yamaha. The Orbital system is also currently used on some small motorcycle and scooter applications by Aprilla. Certification data from various engines certified with DI have shown HC and CO emission reductions of 60 to 75 percent from baseline emission levels.

There is at least one other injection technology that has had success in small two-stroke SI engines used in lawn and garden applications, such as trimmers and chainsaws. Compression Wave technology, referred to as Low Emission (LE) technology, developed by John Deere, uses a compressed air assisted fuel injection system, similar to the Orbital system, to reduce the unburned fuel charge during the scavenging process of the exhaust portion of the two-stroke cycle. The system has shown the ability to reduce HC and CO emissions by up to 75 percent from baseline levels. Although this technology has not yet been applied to any recreational vehicle engines, it appears to have significant potential, especially because of its simplistic design and low cost. For a detailed description of the LE technology, refer to the Nonroad Small SI regulatory support document.

3.2.2.5 - Exhaust Aftertreatment Technologies

There are two exhaust aftertreatment technologies that can provide additional emission reductions from two-stroke engines: thermal oxidation (e.g., secondary air) and oxidation catalyst. Thermal oxidation reduces HC and CO by promoting further oxidation of these species in the exhaust. The oxidation usually takes place in the exhaust port or pipe, and may require the injection of additional air to supply the needed oxygen. If the exhaust temperature can be maintained at a high enough temperature (e.g., 600 to 700°C) for a long enough period, substantial reductions in HC and CO can occur. Air injection at low rates into the exhaust system has been shown to reduce emissions by as much as 77 percent for HC and 64 percent for

CO.[l] However, this was effective only under high-power operating conditions, and the high exhaust temperatures required to achieve this oxidation substantially increased the skin temperature of the exhaust pipe, which can be a concern for off-highway motorcycle applications where the operators legs could come in contact with the pipe.

Like thermal oxidation, the oxidation catalyst is used to promote further oxidation of HC and CO emissions in the exhaust stream, and it also requires sufficient oxygen for the reaction to take place. Some of the requirements for a catalytic converter to be used in two-stroke engines include high HC conversion efficiency, resistance to thermal damage, resistance to poisoning from sulfur and phosphorus compounds in lubricating oil, and low light-off temperature. Additional requirements for catalysts to be used in recreational vehicle two-stroke engines include extreme vibration resistance, compactness, and light weight.

Application of catalytic converters to two-stroke engines presents a problem, because of the high concentrations of HC and CO in their exhaust. If combined with sufficient air, these high pollutant concentrations result in catalyst temperatures that can easily exceed the temperature limits of the catalyst. Therefore, the application of oxidation catalysts to two-stroke engines may first require engine modifications to reduce HC and CO and may also require secondary air be supplied to the exhaust in front of the catalyst.

Researchers of Graz University of Technology and the Industrial Technology Research Institute (ITRI) in Taiwan have published data on the application of catalytic converters in small two-stroke moped and motorcycle engines using catalytic converters. The Graz researchers focused on reducing emissions using catalysts, as well as by improving the thermodynamic characteristics of the engines, such as gas exchange and fuel handling systems, cylinder and piston geometry and configurations, and exhaust cooling systems. For HC and CO emissions, they found that an oxidation catalyst could reduce emissions by 88 to 96 percent. Researchers at ITRI successfully retrofitted a catalytic converter to a 125 cc two-stroke motorcycle engine, and demonstrated both effective emissions control and durability.[m] The Manufacturers of Emission Controls Association (MECA)in their publication titled “Emission Control of Two-and Three-wheel Vehicles,” published May 7, 1999, state that catalyst technology has clearly demonstrated the ability to achieve significant emissions reductions from two-stroke engines. MECA points to the success of two-stroke moped and motorcycle engines equipped with catalysts that have been operating for several years in Taiwan, Thailand, Austria, and Switzerland.

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[l] White, J.J., Carroll,J.N., Hare, C.T., and Lourenco, J.G. (1991), “Emission Control Strategies for Small Utility Engines,” SAE Paper No. 911807, Society of Automotive Engineers, Warrendale, PA, 1991.

[m] Hsien, P.H., Hwang, L.K., and Wang, H.W (1992), “Emission Reduction by Retrofitting a 125 cc Two-Stroke Motorcycle with Catalytic Converter,” SAE Paper No. 922175, Society of Automotive Engineers, Warrendale, PA, 1992.

3.2.3 - Current Four-Stroke Engines

Four-stroke engines are the most common type of engine today. Large nonroad SI engines are exclusively four-stroke. Recreational vehicles are also predominantly four-stroke. Four-stroke engines have considerably lower HC emissions than two-stroke engines, due to the fact that four-stroke engines do not experience short circuiting of raw fuel. CO emissions from four-stroke engines is very similar to two-stroke engines, since CO emissions are the result of inefficient combustion of the air-fuel mixture within the cylinder, typically resulting from rich operation. Since the combustion of fuel within the cylinder of a four-stroke engine is more efficient than that of a two-stroke engine, combustion temperatures are higher, which results in higher NOx emission levels.

The four-stroke engines covered under this rulemaking are typically either automotive engines (large nonroad SI) or motorcycle-like engines (including ATVs). Large nonroad SI engines, off-highway motorcycles, ATVs, and snowmobiles have been unregulated federally. Therefore, while they have relatively low HC emissions compared to two-stroke engines, they can still have high levels of CO (due to rich air-fuel calibration) and NOx. Table 3.2-3 shows baseline emission levels for four-stroke equipped off-highway motorcycles and ATVs.

Table 3.2-3
Baseline Four-Stroke Emissions From Off-Highway Motorcycles & ATVs (g/km)

MC or ATV	Manufacturer	Model	Model Year	Eng. Displ.	HC	CO	NOx
MC	Yamaha	WR250F	20001	249 cc	1.46	26.74	0.110
MC	Yamaha	WR400	1999	399 cc	1.07	20.95	0.112
MC	KTM	400EXC	2001	398 cc	1.17	28.61	0.050
MC	Husaberg	FE501	2001	499 cc	1.30	25.81	0.163
ATV	Kawasaki	Bayou	1989	280 cc	1.17	14.09	0.640
ATV	Honda	300EX	1997	298 cc	1.14	34.60	0.155
ATV	Polaris	Trail Boss	1998	325 cc	1.56	43.41	0.195
ATV	Yamaha	Banshee	1998	349 cc	0.98	19.44	0.190
ATV	Polaris	Sportsman H.O.	2001	499 cc	2.68	56.50	0.295
ATV	Arctic Cat	375 Automatic	2001	375 cc	1.70	49.70	0.190
ATV	Yamaha	Big Bear	2001	400 cc	2.30	41.41	0.170
ATV	Honda	Rancher	2001	400 cc	1.74	33.98	0.150
ATV	Bombardier	4X4 AWD	2001	500 cc	1.62	20.70	0.740
ATV	Polaris	Sportsman	2001	499 cc	1.56	19.21	0.420
ATV	Yamaha	Raptor	2001	660 cc	0.97	16.56	0.210
Average					1.40	28.33	0.245

3.2.4 - Clean Four-Stroke Technologies

The emission-control technologies for four-stroke engines are very similar to those used for two-stroke engines. HC and CO emissions from four-stroke engines are primarily the result of poor in-cylinder combustion. Higher levels of NOx emissions are the result of leaner air-fuel ratios and the resulting higher combustion temperatures. Combustion chamber modifications can help reduce HC emission levels, while using improved air-fuel ratio and spark timing calibrations, as discussed in sections 3.1.3.1 and 3.1.3.2, can further reduce HC emissions and lower CO emissions. The conversion from carburetor to EFI will also help reduce HC and CO emissions. The use of exhaust gas recirculation on Large SI engines can reduce NOx emissions, but is not necessarily needed for recreational vehicles, due to their relatively low NOx emission levels. The addition of secondary air into the exhaust can significantly reduce HC and CO emissions. Finally, the use catalytic converters can further reduce all three emissions.

3.2.4.1. - Combustion chamber design

Unburned fuel can be trapped momentarily in crevice volumes (especially the space between the piston and cylinder wall) before being released into the exhaust. Reducing crevice volumes decreases this amount of unburned fuel, which reduces HC emissions. One way to reduce crevice volumes is to design pistons with piston rings closer to the top of the piston. HC may be reduced by 3 to 10 percent by reducing crevice volumes, with negligible effects on NOx emissions.[4]

HC emissions also come from lubricating oil that leaks into the combustion chamber. The heavier hydrocarbons in the oil generally don't burn completely. Oil in the combustion chamber can also trap gaseous HC from the fuel and prevent it from burning. For engines using catalytic control, some components in lubricating oil can poison the catalyst and reduce its effectiveness, which would further increase emissions over time. To reduce oil consumption, manufacturers can tighten tolerances and improve surface finishes for cylinders and pistons, improve piston ring design and material, and improve exhaust valve stem seals to prevent excessive leakage of lubricating oil into the combustion chamber.

3.2.4.2 - Exhaust gas recirculation

Exhaust gas recirculation (EGR) has been in use in cars and trucks for many years. The recirculated gas acts as a diluent in the air-fuel mixture, slowing reaction rates and absorbing heat to reduce combustion temperatures. These lower temperatures can reduce the engine-out NOx formation rate by as much as 50 percent.[5] HC is increased slightly due to lower temperatures for HC burn-up during the late expansion and exhaust strokes.

Depending on the burn rate of the engine and the amount of recirculated gases, EGR can improve fuel consumption. Although EGR slows the burn rate, it can offset this effect with some benefits for engine efficiency. EGR reduces pumping work since the addition of recirculated gas increases intake pressure. Because the burned gas temperature is decreased, there is less heat loss to the exhaust and cylinder walls. In effect, EGR allows more of the chemical energy in the fuel to be converted to useable work.[6]

For catalyst systems with high conversion efficiencies, the benefit of using EGR becomes proportionally smaller. Also, including EGR as a design variable for optimizing the engine adds significantly to the development time needed to fully calibrate engine models.

3.2.4.3. - Secondary air

Secondary injection of air into exhaust ports or pipes after cold start (e.g., the first 40 to 60 seconds) when the engine is operating rich, coupled with spark retard, can promote combustion of unburned HC and CO in the exhaust manifold and increase the warm-up rate of the catalyst. By means of an electrical or mechanical pump, secondary air is injected into the exhaust system, preferably in close proximity of the exhaust valve. Together with the oxygen of the secondary air and the hot exhaust components of HC and CO, oxidation ahead of the catalyst can bring about an efficient increase in the exhaust temperature which helps the catalyst to heat up quicker. The exothermic reaction that occurs is dependent on several parameters (secondary air mass, location of secondary air injection, engine A/F ratio, engine air mass, ignition timing, manifold and headpipe construction, etc.), and ensuring reproducibility demands detailed individual application for each vehicle or engine design.

Secondary air injection was first used as an emission control technique in itself without a catalyst, and still is used for this purpose in many highway motorcycles and some off-highway motorcycles to meet federal and California emission standards. For motorcycles, air is usually provided or injected by a system of check valves which uses the normal pressure pulsations in the exhaust manifold to draw in air from outside, rather than by a pump.

3.2.4.4 - Catalytic Aftertreatment

Over the last several years, there have been tremendous advances in exhaust aftertreatment systems. Catalyst manufacturers are progressively moving to palladium (Pd) as the main precious metal in automotive catalyst applications. Improvements to catalyst thermal stability and washcoat technologies, the design of higher cell densities, and the use of two-layer washcoat applications are just some of the advances made in catalyst technology. There are two types of catalytic converters commonly used: oxidation and three-way. Oxidation catalysts use platinum and/or palladium to increase the rate of reaction between oxygen in the exhaust and unburned HC and CO. Ordinarily, this reaction would proceed very slowly at temperatures typical of engine exhaust. The effectiveness of the catalyst depends on its temperature, on the air-fuel ratio of the mixture, and on the mix of HC present. Highly reactive species such as formaldehyde and olefins are oxidized more effectively than less-reactive species. Short-chain paraffins such as methane, ethane, and propane are among the least reactive HC species, and are difficult to oxidize.

Three-way catalysts use a combination of platinum and/or palladium and rhodium. In addition to promoting oxidation of HC and CO, these metals also promote the reduction of NO to nitrogen and oxygen. For the NO reduction to occur efficiently, an overall rich or stoichiometric air-fuel ratio is required. The NOx efficiency drops rapidly as the air-fuel ratio becomes leaner than stoichiometric. If the air-fuel ratio can be maintained precisely at or just rich of stoichiometry, a three-way catalyst can simultaneously oxidize HC and CO and reduce NOx. The window of air-fuel ratios within which this is possible is very narrow and there is a trade-off between NOx and CO control even within this window. HC oxidation generally correlates with CO conversion, though changing air-fuel ratios tend to affect CO emissions much more than HC emissions.

There are several issues involved in designing catalytic control systems for the four-stroke engines covered by this rulemaking. The primary issues are the cost of the system, packaging constraints, and the durability of the catalyst. This section addresses these issues.

3.2.4.4.1. - System cost

Sales volumes of industrial and recreational equipment are small compared to automotive sales. Manufacturers therefore have a limited ability to recoup large R&D expenditures for Large SI and recreational engines. For this reason, we believe it is not appropriate to consider highly refined catalyst systems that are tailored specifically to nonroad applications. For Large SI engines, we have based the feasibility of the emission standards on the kind of catalysts that manufacturers have already begun to offer for these engines. These systems are currently produced in very low volumes, but the technology has been successfully adapted to Large SI engines. The cost of these systems will decrease substantially when catalysts become commonplace. Chapter 4 describes the estimated costs for a nonroad catalyst system.

3.2.4.4.2. - Packaging constraints

Large SI engines power a wide range of nonroad equipment. Some of these have no significant space constraints for adding a catalyst. In contrast, equipment designs such as forklifts have been fine-tuned over many years with a very compact fit. The same is even more true for recreational vehicles, such as ATVs and motorcycles.

Automotive catalyst designs typically have one or two catalyst units upstream of the muffler. This is a viable option for most nonroad equipment. However, if there is no available space to add a separate catalyst, it is possible to build a full catalyst/muffler combination that fits in the same space as the conventional muffler. With this packaging option, even compact applications should have little or no trouble integrating a catalyst into the equipment design. The hundreds of catalysts currently operating on forklifts and highway motorcycles clearly demonstrate this.

3.2.5 - Advanced Emission Controls

On February 10, 2000, EPA published new “Light-duty Tier 2" emissions standards for all passenger vehicles, including sport utility vehicles (SUVs), minivans, vans and pick-up trucks. The new standards will ensure that exhaust VOC emissions be reduced to less than 0.1 g/mi on average over the fleet, and that evaporative emissions be reduced by at least 50 percent. Onboard refueling vapor recovery requirements were also extended to medium-duty passenger vehicles. By 2020, these standards will reduce VOC emissions from light-duty vehicles by more than 25 percent of the projected baseline inventory. (See Chapter 4 for a more detailed discussion of the impact of the Light-duty Tier 2 final rule on VOC inventories.) To achieve these reductions, manufacturers will need to incorporate advanced emission controls, including: larger and improved close-coupled catalysts, optimized spark timing and fuel control, improved exhaust systems.

To reduce emissions gasoline-fueled vehicle manufacturers have designed their engines to achieve virtually complete combustion and have installed catalytic converters in the exhaust system. For these controls to work well for gasoline-fueled vehicles, it is necessary to maintain the mixture of air and fuel at a nearly stoichiometric ratio (that is, just enough air to completely burn the fuel). Poor air-fuel mixture can result in significantly higher emissions of incompletely combusted fuel. Current generation highway vehicles are able to maintain stoichiometry by using closed-loop electronic feedback control of the fuel systems. As part of these systems, technologies have been developed to closely meter the amount of fuel entering the combustion chamber to promote complete combustion. Sequential multi-point fuel injection delivers a more precise amount of fuel to each cylinder independently and at the appropriate time increasing engine efficiency and fuel economy. Electronic throttle control offers a faster response to engine operational changes than mechanical throttle control can achieve, but it is currently considered expensive and only used on some higher-price vehicles. The greatest gains in fuel control can be made through engine calibrations—the algorithms contained in the powertrain control module (PCM) software that control the operation of various engine and emission control components/systems. As microprocessor speed becomes faster, it is possible to perform quicker calculations and to increase response times for controlling engine parameters such as fuel rate and spark timing. Other advances in engine design have also been used to reduce engine-out emissions, including: the reduction of crevice volumes in the combustion chamber to prevent trapping of unburned fuel; "fast burn" combustion chamber designs that promote swirl and flame propagation; and multiple valves with variable-valve timing to reduce pumping losses and improve efficiency. These technologies are discussed in more detail in the RIA for the Light-duty Tier 2 final rule.[n]

As noted above, manufacturers are also using aftertreatment control devices to control emissions. New three-way catalysts for highway vehicles are so effective that once a TWC reaches its operating temperature, emissions are virtually undetectable.[o] Manufacturers are now working to improve the durability of the TWC and to reduce light-off time (that is, the amount of time necessary after starting the engine before the catalyst reaches its operating temperature and is effectively controlling VOCs and other pollutants). EPA expects that manufacturers will be able to design their catalyst systems so that they light off within less than thirty seconds of engine starting. Other potential exhaust aftertreatment systems that could further reduce cold-start emissions are thermally insulated catalysts, electrically heated catalysts, and HC adsorbers (or traps). Each of these technologies, which are discussed below, offer the potential for VOC reductions in the future. There are technological, implementation, and cost issues that still need to be addressed, and at this time, it appears that these technologies would not be a cost-effective means of reducing nonroad emissions on a nationwide basis.

Thermally insulated catalysts maintain sufficiently high catalyst temperatures by surrounding the catalyst with an insulating vacuum. Prototypes of this technology have

[n] http://www.epa.gov/otaq/tr2home.htm#Documents. EPA 420-R-99-023

[o] McDonald, J., L. Jones, Demonstration of Tier 2 Emission Levels for Heavy Light-Duty Trucks, SAE 2000-01-1957.

demonstrated the ability to store heat for more than 12 hours.[p] Since ordinary catalysts typically cool down below their light-off temperature in less than one hour, this technology could reduce in-use emissions for vehicles that have multiple cold-starts in a single day. However, this technology would have less impact on emissions from vehicles that have only one or two cold-starts per day.

Electrically-heated catalysts reduce cold-start emissions by applying an electric current to the catalyst before the engine is started to get the catalyst up to its operating temperature more quickly.[q] These systems require a modified catalyst, as well as an upgraded battery and charging system. These can greatly reduce cold-start emissions, but could require the driver to wait until the catalyst is heated before the engine would start to achieve optimum performance.

Hydrocarbon adsorbers are designed to trap VOCs while the catalyst is cold and unable to sufficiently convert them. They accomplish this by utilizing an adsorbing material which holds onto the VOC molecules. Once the catalyst is warmed up, the trapped VOCs are automatically released from the adsorption material and are converted by the fully functioning downstream three-way catalyst. There are three principal methods for incorporating an adsorber into the exhaust system. The first is to coat the adsorber directly on the catalyst substrate. The advantage is that there are no changes to the exhaust system required, but the desorption process cannot be easily controlled and usually occurs before the catalyst has reached light-off temperature. The second method locates the adsorber in another exhaust pipe parallel with the main exhaust pipe, but in front of the catalyst and includes a series of valves that route the exhaust through the adsorber in the first few seconds after cold start, switching exhaust flow through the catalyst thereafter. Under this system, mechanisms to purge the adsorber are also required. The third method places the trap at the end of the exhaust system, in another exhaust pipe parallel to the muffler, because of the low thermal tolerance of adsorber material. Again a purging mechanism is required to purge the adsorbed VOCs back into the catalyst, but adsorber overheating is avoided. One manufacturer who incorporates a zeolite hydrocarbon adsorber in its California SULEV vehicle found that an electrically heated catalyst was necessary after the adsorber because the zeolite acts as a heat sink and nearly negates the cold start advantage of the adsorber. This approach has been demonstrated to effectively reduce cold start emissions.

3.2.5.1 Multiple valves and variable-valve timing

Four-stroke engines generally have two valves for each cylinder, one for intake of the air-fuel mixture and the other for exhaust of the combusted mixture. The duration and lift (distance the valve head is pushed away from its seat) of valve openings is constant regardless of engine speed. As engine speed increases, the aerodynamic resistance to pumping air in and out of the cylinder for intake and exhaust also increases. Automotive engines have started to use two

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[p] Burch, S.D., and J.P. Biel, SULEV and "Off-Cycle" Emissions Benefits of a Vacuum-Insulated Catalytic Convert, SAE 1999-01-0461.

[q] Laing, P.M., Development of an Alternator-Powered Electrically-Heated Catalyst System, SAE 941042.

intake and two exhaust valves to reduce pumping losses and improve their volumetric efficiency and useful power output. Some highway motorcycles have used multiple valves for years, especially the high-performance sport motorcycles.

In addition to gains in breathing, 4-valve designs allow the spark plug to be positioned closer to the center of the combustion chamber, which decreases the distance the flame must travel inside the chamber. This decreases the likelihood of flame-out conditions in the areas of the combustion chamber farthest from the spark plug. In addition, the two streams of incoming gas can be used to achieve greater mixing of air and fuel, further increasing combustion efficiency and lowering engine-out emissions.

Control of valve timing and lift take full advantage of the 4-valve configuration for even greater improvement in combustion efficiency. Engines normally use fixed-valve timing and lift across all engine speeds. If the valve timing is optimized for low-speed torque, it may offer compromised performance under higher-speed operation. At light engine loads, for example, it is desirable to close the intake valve early to reduce pumping losses. Variable-valve timing can enhance both low-speed and high-speed performance with compromise. Variable-valve timing can allow for increased swirl and intake charge velocity, especially during low-load operating conditions where this is most problematic. By providing a strong swirl formation in the combustion chamber, the air-fuel mixture can mix sufficiently, resulting in a faster, more complete combustion, even under lean air-fuel conditions, thereby reducing emissions.

Variable-valve technology by itself may have somewhat limited effect on reducing emissions, but combining it with optimized spark plug location and exhaust gas recirculation can lead to substantial emission reductions.

3.3 - Evaporative Emissions

3.3.1 Sources of Evaporative Emissions

Evaporative emissions from nonroad SI equipment represents a small but significant part of their NMHC emissions. The significance of the emissions varies widely depending on the engine design and application. LPG-fueled equipment generally has very low evaporative emissions because of the tightly sealed fuel system. At the other extreme, carbureted gasoline-fueled equipment with open vented tanks can have very high evaporative emissions. Evaporative emissions can be grouped into five categories:

DIURNAL: Gasoline evaporation increases as the temperature rises during the day, heating the fuel tank and venting gasoline vapors.

RUNNING LOSSES: The hot engine and exhaust system can vaporize gasoline when the engine is running.

HOT SOAK: The engine remains hot for a period of time after the engine is turned off and gasoline evaporation continues.

REFUELING: Gasoline vapors are always present in typical fuel tanks. These vapors are forced out when the tank is filled with liquid fuel.

PERMEATION: Gasoline molecules can saturate plastic fuel tanks and rubber hoses, resulting in a relatively constant rate of emissions as the fuel continues to permeate through these components.

Among the factors that affect emission rates are: (1) fuel metering (fuel injection or carburetor); (2) the degree to which fuel permeates fuel lines and fuel tanks; (3) the proximity of the fuel tank to the exhaust system or other heat sources; (4) whether the fuel system is sealed and the pressure at which fuel vapors are vented; and (5) fuel tank volume.

3.3.1.1 - Diurnal and Running Loss Emissions

In an open fuel tank, the vapor space is at atmospheric pressure (typically about 14.7 psi), and contains a mixture of fuel vapor and air. At all temperatures below the fuel's boiling point, the vapor pressure of the fuel is less than atmospheric pressure. This is also called the partial pressure of the fuel vapor. The partial pressure of the air is equal to the difference between atmospheric pressure and the fuel vapor pressure. For example, in an open-vented fuel tank at 60˚F, the vapor pressure of typical gasoline would be about 4.5 psi. In this example, the partial pressure of the air would be about 10.2 psi. Assuming that the vapor mixture behaves as an ideal gas, then the mole fractions (or volumetric fractions) of fuel vapor and air would be equal to their respective partial pressures divided by the total pressure; thus, the fuel would be 31 percent of the mixture (4.5/14.7) and the air would be 69 percent of the mixture (10.2/14.7).

Diurnal emissions occur when the fuel temperature increases, which increases the equilibrium vapor pressure of the fuel. For example, assume that the fuel in the previous example was heated to 90˚F, where the vapor pressure that same typical fuel would be about 8.0 psi. To maintain the vapor space at atmospheric pressure, the partial pressure of the air would need to decrease to 6.7 psi, which means that the vapor mixture must expand in volume. This forces some of the fuel-air mixture to be vented out of the tank. When the fuel later cools, the vapor pressure of the fuel decreases, contracting the mixture, and drawing fresh air in through the vent. When the fuel is heated again, another cycle of diurnal emissions occurs. It is important to note that this is generally not a rate-limited process. Although the evaporation of the fuel can be slow, it is generally fast enough to maintain the fuel tank in an essentially equilibrium state.

Consider a typical fuel use cycle beginning with a full tank. As fuel is used by the engine, and the liquid fuel volume decreases, air is drawn into the tank to replace the volume of the fuel. (Note: the decrease in liquid fuel could be offset to some degree by increasing fuel vapor pressure caused by increasing fuel temperature.) This would continue while the engine was running. If the engine was shut off and the tank was left overnight, the vapor pressure of the fuel would drop as the temperature of the fuel dropped. This would cause a small negative pressure within the tank that would cause it to fill with more air until the pressure equilibrated. The next day, the vapor pressure of the fuel would increase as the temperature of the fuel increased. This would cause a small positive pressure within the tank that would force a mixture of fuel vapor and air out. In poorly designed gasoline systems, where the exhaust is very close to the fuel tank, the fuel can actually begin to boil. When this happens, large amounts of gasoline vapor can be vented directly to the atmosphere. Southwest Research Institute measured emissions from several large nonroad gasoline engines and found them to vary from about 12 g/day up to almost 100 g/day. They also estimated that a typical large nonroad gasoline engine in the South Coast Air Basin (the area involved in their study) would have an evaporative emission rate of about 0.4 g/kW-hr.

3.3.1.2 - Hot Soak Emissions

Hot soak emissions occur after the engine is turned off, especially during the resulting temperature rise. For nonroad engines, the primary source of hot soak emissions is the evaporation of the fuel left in the carburetor bowl. Other sources can include increased permeation and evaporation of fuel from plastic or rubber fuel lines in the engine compartment.

3.3.1.3 - Refueling Emissions

Refueling emissions occur when the fuel vapors are forced out when the tank is filled with liquid fuel. At a given temperature, refueling emissions are proportional to the volume of the fuel dispensed into the tank. Every gallon of fuel put into the tank forces out one-gallon of the mixture of air and fuel vapors. Thus, refueling emissions are highest when the tank is near empty. Refueling emissions are also affected by the temperature of the fuel vapors. At low temperatures, the fuel vapor content of the vapor space that is replaced is lower than it is at higher temperatures.

3.3.1.4 - Permeation

The polymeric material (plastic or rubber) of which many gasoline fuel tanks and fuel hoses generally have a chemical composition much like that of gasoline. As a result, constant exposure of gasoline to these surfaces allows the material to continually absorb fuel. The outer surfaces of these materials are exposed to ambient air, so the gasoline molecules permeate through these fuel-system components and are emitted directly into the air. Permeation rates are relatively low, but emissions continue at a nearly constant rate, regardless of how much the vehicle or equipment is used. Permeation-related emissions can therefore add up to a significant fraction of the total emissions from gasoline powered vehicles.

3.3.2 Evaporative Emission Controls

Several emission-control technologies can be used to reduce evaporative emissions. The advantages and disadvantages of the various possible emission-control strategies are discussed below. Chapter 4 presents more detail on how we expect manufacturers to use these technologies to meet the emission standards for the individual applications.

3.3.2.1 - Sealed System with Pressure Relief

Evaporative emissions are formed when the fuel heats up, evaporates, and passes through a vent into the atmosphere. By closing that vent, evaporative emissions are prevented from escaping. However, as vapor is generated, pressure builds up in fuel tank. Once the fuel cools back down, the pressure subsides.

For forklifts, the primary application of Large SI engines, Underwriters Laboratories specifies that units operating in certain areas where fire risk is most significant must use pressurized fuel tanks. Underwriters Laboratories requires that trucks use self-closing fuel caps with tanks that stay sealed to prevent evaporative losses; venting is allowed for positive pressures above 3.5 psi or for vacuum pressures of at least 1.5 psi.[r] These existing requirements are designed to prevent evaporative losses for safety reasons. This same approach for other types of engines would similarly reduce emissions for air-quality reasons.

An alternative to using a pressure relief valve to hold vapors in the fuel tank would be to use a limited flow orifice. However, the orifice size may be so small that there would be a risk of fouling. In addition, an orifice designed for a maximum of 2 psi under worst case conditions may not be very effective at lower temperatures. One application where a limited flow orifice may be useful is if it is combined with an insulated fuel tank as discussed below.

3.3.2.2 - Insulated Fuel Tank

Another option for reducing diurnal emissions is insulating the fuel tank. Rather than capturing the vapors in the fuel tank, this strategy would minimize the fuel heating which therefore minimizes the vapor generation. However, significant evaporative emissions would still occur through the vent line due to diffusion even without temperature gradients. A limited-flow orifice could be used to minimize the to loss of vapor through the vent line due to diffusion. In this case, the orifice could be sized to prevent diffusion losses without causing pressure build-up in the tank. Additional control could be achieved with the use of a pressure relief valve or a smaller limited flow orifice. Note that an insulated tank could maintain the same emission control with a lower pressure valve than a tank that was not insulated.

3.3.2.3 - Volume-Compensating Air Bag

Another concept for minimizing pressure in a sealed fuel tank is through the use of a volume-compensating air bag. The purpose of the bag is to fill up the vapor space in the fuel tank above the fuel itself. By minimizing the vapor space, less air is available to mix with the heated fuel and less fuel evaporates. As vapor is generated in the small vapor space, air is forced

[r] UL558, paragraphs 26.1 through 26.4

out of the air bag, which is vented to atmosphere. Because the bag collapses as vapor is generated, the volume of the vapor space grows and no pressure is generated. Once the fuel tank cools as ambient temperature goes down, the resulting vacuum in the fuel tank will open the bag back up. Depending on the size of the bag, pressure in the tank could be minimized; therefore, the use of a volume-compenating air bag could allow a manufacturer to reduce the pressure limit on its relief valve.

3.3.2.4 - Collapsible Bladder Fuel Tank

Probably the most effective technology for reducing evaporative emissions from fuel tanks is through the use of a collapsible fuel bladder. In this concept, a non-permeable bladder would be installed in the fuel tank to hold the fuel. As fuel is drawn from the bladder, the vacuum created collapses the bladder. Therefore, there is no vapor space and no pressure build up. Because the bladder would be sealed, there would be no vapors vented to the atmosphere.

3.3.2.5 - Charcoal Canister

The primary evaporative emission control device used in automotive applications is a charcoal canister. With this technology, vapor generated in the tank is vented through a charcoal canister. The activated charcoal collects and stores the hydrocarbons. Once the engine is running, purge air is drawn through the canister and the hydrocarbons are burned in the engine. These charcoal canisters generally are about a liter in size and have the capacity to store three days of vapor over the test procedure conditions.

For industrial applications, engines are typically used frequently which would limit the size of canister needed; however, introducing an evaporative canister is a complex undertaking, requiring extensive efforts to integrate evaporative and exhaust emission-control strategies. Large SI engine manufacturers also often sell loose engines to equipment manufacturers, who would also need to integrate the new technology into equipment designs.

3.3.2.6 - Floating Fuel and Vapor Separator

Another concept used in some stationary engine applications is a floating fuel and vapor separator. Generally small, impermeable plastic balls are floated in the fuel tank. The purpose of these balls is to provide a barrier between the surface of the fuel and the vapor space. However, this strategy does not appear to be viable for industrial fuel tanks. Because of the motion of the equipment, the fuel sloshes and the barrier would be continuously broken. Even small movements in the fuel could cause the balls to rotate and transfer fuel to the vapor space.

3.3.2.7 - Permeation Barriers

Another source of evaporative emissions is permeation through the walls of plastic fuel tanks and rubber hoses.

3.3.2.7.1 Fuel Tanks

Blow molding is widely used for the manufacture of small fuel tanks of recreational vehicles. Typically, blow molding is performed by creating a hollow tube, known as a parison, by pushing high-density polyethylene (HDPE) through an extruder with a screw. The parison is then pinched in a mold and inflated with an inert gas. In highway applications, non-permeable plastic fuel tanks are produced by blow molding a layer of ethylene vinyl alcohol (EVOH) or nylon between two layers of polyethylene. This process is called coextrusion and requires at least five layers: the barrier layer, adhesive layers on either side of the barrier layer, and HDPE as the outside layers which make up most of the thickness of the fuel tank walls. However, multi-layer construction requires two additional extruder screws which significantly increases the cost of the blow molding process.

Multi-layer fuel tanks can also be formed using injection molding. In this method, a low viscosity polymer is forced into a thin mold to create each side of the fuel tank. The two sides are then welded together. In typical fuel tank construction, the sides are welded together by using a hot plate for localized melting and then pressing the sides together. The sides may also be connected using vibration or sonic welding. To add a barrier layer, a thin sheet of the barrier material is placed inside the mold prior to injection of the poleythylene. The polyethylene, which generally has a much lower melting point than the barrier material, bonds with the barrier material to create a shell with an inner liner. As an alternative, an additional extruder can be added to inject the barrier layer prior to injecting the HDPE; however, this substantially increases the cost of the process.

A less expensive alternative to coextrusion is to blend a low permeable resin in with the HDPE and extrude it with a single screw. The trade name typically used for this permeation control strategy is Selar®. The low permeability resin, typically EVOH or nylon, creates non-continuous platelets in the HDPE fuel tank which reduce permeation by creating long, tortuous pathways that the hydrocarbon molecules must navigate to pass through the fuel tank walls. Although the barrier is not continuous, this strategy can still achieve greater than a 90 percent reduction in permeation of gasoline. EVOH has much higher permeation resistance to alcohol than nylon; therefore, it would be the preferred material to use for meeting our standard which is based on testing with a 10 percent ethanol fuel.

Another type of low permeation technology for fuel tanks would be to treat the surfaces of a plastic fuel tanks with a barrier layer. Two ways of achieving this are known as fluorination and sulfonation. The fluorination process causes a chemical reaction where exposed hydrogen atoms are replaced by larger fluorine atoms which a barrier on surface of the fuel tank. In this process, fuel tanks are generally processed post production by stacking them in a steel container. The container is then be voided of air and flooded with fluorine gas. By pulling a vacuum in the container, the fluorine gas is forced into every crevice in the fuel tanks. As a result of this process, both the inside and outside surfaces of the fuel tank would be treated. As an alternative, fuel tanks can be fluorinated on-line by exposing the inside surface of the fuel tank to fluorine during the blow molding process. However, this method may not prove as effective as off-line fluorination which treats the inside and outside surfaces.

Sulfonation is another surface treatment technology where sulfur trioxide is used to create the barrier by reacting with the exposed polyethylene to form sulfonic acid groups on the surface. Current practices for sulfonation are to place fuel tanks on a small assembly line and expose the inner surfaces to sulfur trioxide, then rinse with a neutralizing agent. However, can also be performed off-line. Either of these processes can be used to reduce gasoline permeation by more than 95 percent.

3.3.2.7.2 Fuel Hoses

Fuel hoses produced for use in recreational vehicles are generally extruded nitrile rubber with a cover for abrasion resistance. Lower permeability fuel hoses produced today for other applications are generally constructed in one of two ways: either with a low permeability layer or by using a low permeability rubber blend. By using hose with a low permeation thermoplastic layer, permeation emissions can be reduced by more than 95 percent. Because the thermoplastic layer is very thin, on the order of 0.1 to 0.2 mm, the rubber hose retains its flexibility. Two thermoplastics which have excellent permeation resistance, even with an alcohol-blend fuel, are ethylene-tetrafluoro-ethylene (ETFE) and tetra-fluoro-ethylene, hexa-fluoro-propylene, and vinyledene fluoride (THV).

In automotive applications, multilayer plastic tubing, made of fluoropolymers is generally used. An added benefit of these low permeability lines is that some fluoropolymers can be made to conduct electricity and therefore can prevent the buildup of static charges. Although this technology can achieve more than an order of magnitude lower permeation than barrier hoses, it is relatively inflexible and may need to be molded in specific shapes for each recreational vehicle design. Manufacturers have commented that they would need flexible hose to fit their many designs, resist vibration, and to simplify the hose connections and fittings.

An alternative approach to reducing the permeability of marine hoses would be to apply a surface treatment such as fluorination or sulfonation. This process would be performed in a manner similar to discussed above for fuel tanks.

3.4 CI Recreational Marine Engines

In this section, we discuss how emissions can be reduced from compression-ignition (CI) recreational marine engines. We believe recreational marine diesel engines can use the same technology for reducing emissions that will be used to meet the standards for commercial marine diesel engines.[7] Because of the similarities between recreational and commercial diesel engines, this chapter builds off the technological analysis in the Regulatory Impact Analysis for the commercial diesel marine engine rule.[8] This section discusses emissions formation, baseline technology, control strategies for CI recreational marine engines.

3.4.1 Background on Emissions Formation from Diesel Engines

Most, if not all, of compression-ignition recreational marine engines use diesel fuel. For this reason, we focus on recreational marine diesel engines in this section. In a diesel engine, the liquid fuel is injected into the combustion chamber after the air has been heated by compression (direct injection), or the fuel is injected into a prechamber, where combustion initiates before spreading to the rest of the combustion chamber (indirect injection). The fuel is injected in the form of a mist of fine droplets or vapor that mix with the air. Power output is controlled by regulating the amount of fuel injected into the combustion chamber, without throttling (limiting) the amount of air entering the engine. The compressed air heats the injected fuel droplets, causing the fuel to evaporate and mix with the available oxygen. At several sites where the fuel mixes with the oxygen, the fuel auto-ignites and the multiple flame fronts spread through the combustion chamber.

NOx and PM are the emission components of most concern from diesel engines. Incomplete evaporation and burning of the fine fuel droplets or vapor result in emissions of the very small particles of PM. Small amounts of lubricating oil that escape into the combustion chamber can also contribute to PM. Although the fuel-air ratio in a diesel cylinder is very lean, the air and fuel are not a homogeneous charge as in a gasoline engine. As the fuel is injected, the combustion takes place at the flame-front where the fuel-air ratio is near stoichiometry (chemically correct for combustion). At localized areas, or in cases where light-ends have vaporized and burned, molecules of carbon remain when temperatures and pressures in the cylinder become too low to sustain combustion as the piston reaches bottom dead center. Therefore, these heavy products of incomplete combustion are exhausted as PM.

NOx formation requires high temperatures and excess oxygen which are found in a diesel engine. Therefore, the diesel combustion process can cause the nitrogen in the air to combine with available oxygen to form NOx. High peak temperatures can be seen in typical unregulated diesel engine designs. This is because the fuel is injected early to help lead to more complete combustion, therefore, higher fuel efficiency. If fuel is injected too early, significantly more fuel will mix with air prior to combustion. Once combustion begins, the premixed fuel will burn at once leading to a very high temperature spike. This high temperature spike, in turn, leads to a high rate of NOx formation. Once combustion begins, diffusion burning occurs while the fuel is being injected which leads to a more constant, lower temperature, combustion process.

Because of the presence of excess oxygen, hydrocarbons evaporating in the combustion chamber tend to be completely burned and HC and CO are not emitted at high levels. Evaporative emissions from diesel engines are insignificant due to the low evaporation rate of diesel fuel.

Controlling both NOx and PM emissions requires different, sometimes opposing strategies. The key to controlling NOx emissions is reducing peak combustion temperatures since NOx forms at high temperatures. In contrast, the key to controlling PM is higher temperatures in the combustion chamber or faster burning. This reduces PM by decreasing the formation of particulates and by oxidizing those particulates that have formed. To control both NOx and PM, manufacturers need to combine approaches using many different design variables to achieve optimum performance. These design variables are discussed in more detail below.

3.4.2 Marinization Process

Like commercial marine engines, recreational marine engines are not generally built from the ground up as marine engines. Instead, they are often marinized land-based engines. The main difference between recreational and commercial marine engines is the application for which they are designed. Commercial engines are designed for high hours of use. Recreational engines are generally designed for higher power, but less hours of use. The following is a brief discussion of the marinization process, as it is performed by either engine manufacturers or post-manufacture marinizers (PMM).

3.4.2.1 Process common to all marine diesel engines

The most obvious changes made to a land-based engine as part of the marinization process concern the engine's cooling system. Marine engines generally operate in closed compartments without much air flow for cooling. This restriction can lead to engine performance and safety problems. To address engine performance problems, these engines make use of the ambient water to draw the heat out of the engine coolant. To address safety problems, marine engines are designed to minimize hot surfaces. One method of ensuring this, used mostly on smaller marine engines, is to run cooling water through a jacket around the exhaust system and the turbocharger. Larger engines generally use a thick insulation around the exhaust pipes.

Hardware changes associated with these cooling system changes often include water jacketed turbochargers, water cooled exhaust manifolds, heat exchangers, sea water pumps with connections and filters, and marine gear oil coolers. In addition, because of the greater cooling involved, it is often necessary to change to a single-chamber turbocharger, to avoid the cracking that can result from a cool outer wall and a hot chamber divider.

Marinization may also involve replacing engine components with similar components that are made of materials that are more carefully adapted to the marine environment. Material changes include more use of chrome and brass including changes to electronic fittings to resist water induced corrosion. Zinc anodes are often used to prevent engine components, such as raw-water heat exchangers, from being damaged by electrolysis.

3.4.2.2 Process unique to recreational marine diesel engines

Other important design changes are related to engine performance. Especially for planing hull vessels used in recreational and light duty commercial marine applications, manufacturers strive to maximize the power-to-weight ratio of their marine engines, typically by increasing the power from a given cylinder displacement. The most significant tool to accomplish this is the fuel injection system: the most direct way to increase power is to inject more fuel. This can require changes to the camshaft, cylinder head, and the injection timing and pressure.

Design limits for increased fuel to the cylinder are smoke and durability. Modifications made to the cooling system also help enhance performance. By cooling the charge, more air can be forced into the cylinder. As a result, more fuel can be injected and burned efficiently due to the increase in available oxygen. In addition, changes are often made to the pistons, cylinder head components, and the lubrication system. For instance, aluminum piston skirts may be used to reduce the weight of the pistons. Cylinder head changes include changing valve timing to optimize engine breathing characteristics. Increased oil quantity and flow may be used to enhance the durability of the engine.

Depending on the stage of production and the types of changes made, the marinization process can have an impact on the base engine’s emission characteristics. In other words, a land-based engine that meets a particular set of emission limits may no longer meet these limits after it is marinized. This can be the case, for example, if the fuel system is changed to enhance engine power or if the cooling system no longer achieves the same degree of engine cooling as that of the base engine. Because marine diesel engines are currently unregulated, engine manufacturers have been able to design their marine engines to maximize performance. Especially for recreational marine engines, manufacturers often obtain power/weight ratios much higher than for land-based applications.

Recreational engine manufacturers strive for higher power/weight ratios than are necessary for commercial marine engines. Because of this, recreational marine engines use technology we projected to be used by commercial marine engines to meet the Tier 2 emissions standards such as raw-water aftercooling and electronic control. However, this technology is used to gain more power rather than to reduce emissions. The challenge presented by the emission control program will be to achieve the emission limits while maintaining favorable performance characteristics.

3.4.3 General Description of Technology for Recreational Marine Diesel Engines

We believe that the standards can be met using technology that has been developed for and used on land-based nonroad and highway engines. The Regulatory Impact Analysis for the commercial marine final rule includes a lengthy description of emission control technology for diesel marine engines. Table 3.4-1 outlines this description. By combining the strategies shown below, manufacturers can optimize the emissions and performance of their engines. We anticipate that the same percent reductions achievable on commercial marine engines would be achievable on recreational marine engines using the same technology. The same technology is used in land-based applications to achieve even a higher magnitude of emission reduction. In addition, this technology works consistently across the engine map encompassed by the NTE zone. A more detailed analysis of the application of several of these technologies to recreational marine engines is discussed in Chapter 4. The costs associated with applying these systems are considered in Chapter 5.

Table 3.4-1: Emission Control Strategies for Marine Diesel Engines

Technology	Description	HC	CO	NOx	PM
Combustion optimization:	timing retard–reduce peak cylinder temperatures by shortening the premixed burning phase	↑	↑	↓↓	↑↑
	reduced crevice volume–such as raising the top piston ring	↓	↓	↔	↓
	geometry–match piston crown geometry to injector spray	↓	↓	↓	↓
	increased compression ratio–raises cylinder pressures	↓	↓	↑	↓
	increased swirl–control of air motion for better mixing	↓	↓	↑,↔	↓
Advanced fuel injection controls	increased injection pressure–better atomization of fuel	↓	↓	↑,↔	↓
	nozzle geometry–optimize spray pattern	↓	↓	↓	↓
	valve-closed orifice–minimize leakage after injection	↓	↔	↔	↓
	rate shaping–inject small amount of fuel early to begin combustion to reduce premixed burning	↔	↔	↓	↔
	common rail–high pressure rail to injectors, excellent control of fuel rate, pressure, and timing	↓	↓	↓	↓
Improving charge air characteristics	turbocharging–increases available oxygen in the cylinder but heats intake air	↓	↓	↑	↓
	jacket-water aftercooling–uses engine coolant to cool charged air which increases available oxygen in cylinder	↔	↔	↓	↔
	raw-water aftercooling–uses ambient water to cool charge air; more effective than jacket-water aftercooling; may result in additional maintenance such as changing anodes	↔	↔	↓↓	↔
Electronic control	better control of fuel system including rate, pressure, and timing especially under transients; can use feedback loop	↓	↓	↓	↓
Exhaust gas recirculation	hot EGR–recirculated exhaust gas reduces combustion temperatures by absorbing heat and slowing reaction rates	↑	↑	↓	↑
	cooled EGR–reduces volume of recirculated gases so to allow more oxygen in the cylinder	↔	↔	↓↓	↑,↔
	soot removal–soot in recirculated gases may cause durability problems at high EGR rates; gas filter or trap; oil filter	↔	↔	↔	↓
Exhaust aftertreatment devices (would require "dry" exhaust)	oxidation catalyst–oxidizes hydrocarbons and soluble organic fraction of PM; will be poisoned by high levels of sulfur	↓	↓	↔	↓
	particulate trap–collect PM; use catalyst to regenerate at high temperature	↓	↓	↔	↓
	selective catalytic reduction–uses a catalyst and a reducing	↔	↔	↓	↔

Water emulsification	water is mixed with fuel or injected into the cylinder; water has a high heat capacity and will lower in-cylinder temperatures	↔	↔	↓	↔

Chapter 3 References

1. Heywood, J., “Internal Combustion Engine Fundamentals,” McGraw-Hill, Inc., New York, 1988, pp.829-836, Docket A-2000-01, Document IV-A-110.

2. Heywood, pp.827-829, Docket A-2000-01, Document IV-A-110.

3. Saikalis, G., Byers, R., Nogi., T., “Study on Air Assist Fuel Injector Atomization and Effects on Exhaust Emission Reduction,” SAE Paper 930323, 1993, Docket A-2000-01, Document II-A-55.

4. Energy and Environmental Analysis, “Benefits and Cost of Potential Tier 2 Emission Reduction Technologies”, Final Report, November 1997, Docket A-2000-01, Document II-A-01.

5. Southwest Research Institute, “Three-Way Catalyst Technology for Off-Road Equipment Powered by Gasoline and LPG Engines,” prepared for California ARB, California EPA, and South Coast Air Quality Management District, (SwRI 8778), April 1999, Docket A-2000-01, Document II-A-08.

6. Heywood, pp. 836-839, Docket A-2000-01, Document IV-A-110.

7. “Control of Emissions of Air Pollution from New Marine Compression-Ignition Engines at or Above 37 kW; Final Rule,” 64 FR 73318, December 29, 1999.

8. Final Regulatory Impact Analysis for “Control of Emissions of Air Pollution from New Marine Compression-Ignition Engines at or Above 37 kW; Final Rule,” November 1999, Docket A-2000-01, Document II-A-78.

Chapter 4: Feasibility of Standards

Section 213(a)(3) of the Clean Air Act presents statutory criteria that EPA must evaluate in determining standards for nonroad engines and vehicles. The standards must "achieve the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the engines or vehicles to which such standards apply, giving appropriate consideration to the cost of applying such technology within the period of time available to manufacturers and to noise, energy, and safety factors associated with the application of such technology." This chapter presents the technical analyses and information that form the basis of EPA's belief that the emission standards are technically achievable accounting for all the above factors.

It is important to note that the term "greatest degree of emission reduction achievable" applies with respect to in-use emissions from each production engine at the end of engine's useful life, rather than what is achievable under more ideal laboratory conditions. This means that the standards that are being established in this rulemaking must account for production variability and for deterioration in emission performance that will occur in use as the engines age and wear over the applicable useful life periods. We have considered these factors in determining the lowest emissions that will be feasible in the time frame required. Thus, in some cases, the emission standards are somewhat higher than the lowest emissions observed during laboratory testing. In general, we expect that manufacturers will design their engines and vehicles to be at 10- 20 percent below the applicable emission standard when produced to account for both production variability and deterioration. Chapter 6 includes more information about our expectations regarding compliance margins and deterioration rates.

4.1 CI Recreational Marine

The emission standards for CI recreational marine engines are summarized in the Executive Summary. We believe that manufacturers will be able to meet these standards using technology similar to that required for the commercial marine engine standards. This section discusses technology currently used on CI recreational marine engines and anticipated technology to meet the standards. In addition, this section discusses the emission test procedures and Not-to-Exceed requirements.

4.1.1 Baseline Technology for CI Recreational Marine Engines

We developed estimates of the current mix of technology for CI recreational marine engines based on data from the 1999 Power Systems Research (PSR) database and from conversations with marine manufacturers. Based on this information, we estimate that 97 % of new marine engines are turbocharged, and 80% of these turbocharged engines use aftercooling. The majority of these engines are four-stroke, but about 14% of new engines are two-stroke. Electronic controls have only recently been introduced into the marketplace; however, we anticipate that their use will increase as customers realize the performance benefits associated with electronic controls and as the natural migration of technology from on-highway to nonroad to marine engine applications occurs.

Table 4.1-1 presents data[1,2,3,4,5,6] from 25 recreational marine diesel engines based on the ISO E5 duty cycle. This data shows to what extent emissions need to be reduced from today's CI recreational marine engines to meet the standards.[s] On average, we are requiring significant reductions in HC+NOx and PM. However, this data seems to show that the diesel engine designs will either have to be focused on NOx or PM due to the trade-off between calibrating to minimize these pollutants. The CO standard will act more as a cap, but will require control to be established.

[s] For most of the engines in Table 4.1-1, the standards are of 7.2 g/kW-hr HC+NOx, 5 g/kW-hr CO, and 0.2 g/kW-hr PM

Table 4.1-1: Emissions Data from CI Recreational Marine Engines

Rated Power (kW)	Control Management	Aftercooling	Emissions Data (g/kW-hr)			
			HC	NOx	CO	PM
120	electronic	raw-water	0.09	5.8	0.9	–
132	mechanical	raw-water	0.07	4.2	0.2	–
142	mechanical	separate circuit	0.79	8.6	1.1	–
162	mechanical	raw-water	0.11	4.0	0.2	–
164	electronic	raw-water	0.28	5.1	1.6	–
170	mechanical	raw-water	0.36	8.1	0.6	0.20
186	mechanical	raw-water	0.30	10.2	1.2	0.12
209	mechanical	raw-water	0.42	10.8	2.3	0.22
230	electronic	raw-water	0.28	5.5	1.8	0.39
235	mechanical	raw-water	0.45	9.8	1.8	0.20
265	mechanical	jacket-water	0.58	10.8	1.4	–
276	mechanical	raw-water	0.60	10.7	1.9	0.24
287	electronic	raw-water	0.28	7.9	–	0.12
321	mechanical	raw-water	0.37	7.7	0.9	0.23
324	mechanical	jacket-water	0.30	7.9	2.9	0.95
336	electronic	jacket-water	0.18	11.0	0.5	0.10
336	electronic	jacket-water	0.09	11.9	–	0.16
447	electronic	raw-water	0.12	9.3	–	0.17
447	mechanical	jacket-water	0.60	12.0	1.5	0.18
474	electronic	raw-water	0.34	7.7	0.5	0.07
537	electronic	jacket-water	0.08	10.7	–	0.19
820	electronic	separate circuit	0.33	9.5	0.8	0.13
1040	electronic	jacket-water	0.09	9.3	–	0.21
1080	electronic	separate circuit	0.18	7.6	1.2	0.15
1340	electronic	separate circuit	0.27	7.2	0.9	0.15

4.1.2 Anticipated Technology for CI Recreational Marine Engines

Marine engines are generally derived from land-based nonroad, locomotive, and to some extent highway engines. In addition, recreational marine engines will be able to use technology developed for commercial marine engines. This allows recreational marine engines, which generally have lower sales volumes than other nonroad engines, to be produced more cost-efficiently. Because the marine designs are derived from land-based engines, we believe that many of the emission-control technologies which are likely to be applied to nonroad engines to meet their Tier 2 and 3 emission standards will be applicable to marine engines. We also believe that the technologies listed below will be sufficient for meeting both the new emission standards and the Not to Exceed requirements discussed later in this chapter for the full useful life of these engines.

We anticipate that timing retard will likely be used in most CI recreational marine applications, especially at cruising speeds, to gain NOx reductions. The negative impacts of timing retard on HC, PM, fuel consumption and power can be offset with improved fuel injection systems with higher fuel injection pressures, optimized nozzle geometry, and potentially through injection rate shaping. We do not expect marine engine manufacturers to convert from direct injection to indirect injection due to these standards.

Regardless of environmental regulations, we believe that recreational marine engine manufacturers will make more use of electronic engine management controls in the future to satisfy customer demands of increased power and fuel economy. Through the use of electronic controls, additional reductions in HC, CO, NOx, and PM can be achieved. Electronics may be used to optimize engine calibrations under a wider range of operation. Most of the significant research and development for the improved fuel injection and engine management systems should be accomplished for land-based nonroad diesel engines which are being designed to meet Tier 2 and Tier 3 standards. Common rail should prove to be a useful technology for meeting even lower emission levels in the future, especially for smaller engines. Thus, the challenge for this control program will be transferring land-based techniques to marine engines.

We project that all CI recreational marine engines will be turbocharged and most will be aftercooled to meet emission standards. Aftercooling strategies will likely be mostly jacket-water charge air cooling, and in some cases, we believe that separate cooling circuits for the aftercooling will be used. We do not expect a significant increase in the use of raw-water charge air cooling for marine engines as a result of this rule. We recognize that raw-water aftercooling systems are currently in use in many applications. Chapter 5 presents one possible scenario of how these technologies could be used on CI recreational marine engines to meet the standards.

By adopting standards that will not go into effect until 2006, we are providing engine manufacturers with substantial lead time for developing, testing, and implementing emission control technologies. This lead time and the coordination of standards with those for commercial marine engines allows for a comprehensive program to integrate the most effective emission control approaches into the manufacturers' overall design goals related to performance, durability, reliability, and fuel consumption.

4.1.3 Emission Measurement Procedures for CI Recreational Marine Engines

In any program we design to achieve emissions reductions from internal combustion engines, the test procedures we use to measure emissions are as important as the standards we put into place. These test procedure issues include duty cycle for certification, in-use verification testing, emission sampling methods, and test fuels.

4.1.3.1 Certification Duty Cycles

In choosing duty cycles for certification, we turned to the International Standards Organization (ISO).[7] For CI recreational marine engines, we based our standards on the ISO E5 duty cycle. This duty cycle is intended for "diesel engines for craft less than 24m length (propeller law)."

We specify the E5 duty cycle for measuring emissions from CI recreational marine engines. This cycle is similar to the E3 duty cycle which is used for commercial marine in that both cycles have four steady-state test points on an assumed cubic propeller curve. However, the E5 includes an extra mode at idle and has an average weighted power of 34% compared to the 69% for the E3. This duty cycle is presented in Table 4.1-2.

Table 4.1-2: ISO E5 Marine Duty Cycle

Mode	% of Rated Speed	% of Power at Rated Speed	Weighting Factor
1	100	100	0.08
2	91	75	0.13
3	80	50	0.17
4	63	25	0.32
5	idle	0	0.30

4.1.3.2 Emission Control of Typical In-Use Operation

We are concerned that if a marine engine is designed for low emissions on average over a small number of discrete test points, it may not necessarily operate with low emissions in-use. This is due to a range of speed and load combinations that can occur on a boat which do not necessarily lie on the test duty cycles. For instance, the test modes for the E5 duty cycle lie on average propeller curves. However, a propulsion marine engine may never be fitted with an "average propeller." In addition, a given engine on a boat may operate at higher torques than average if the boat is heavily loaded. We are also aware that, before a boat comes to plane, the engine operates closer to its full torque map than to the propeller curve.

We are applying the "Not-to-Exceed" (NTE) limit concept to recreational marine engines in a way that is similar to commercial marine engines. This concept basically picks a zone of operation under which a marine engine must not exceed the standard by a fixed percentage and is discussed in more detail in the commercial marine FRM.[8] Of course, the shape of the zone must be adjusted to reflect recreational engine use.

Under this final rule, we have the authority to use test data from new or in-use engines to confirm emissions compliance throughout an engine's useful life.

4.1.3.2.1 Engine operation included for NTE

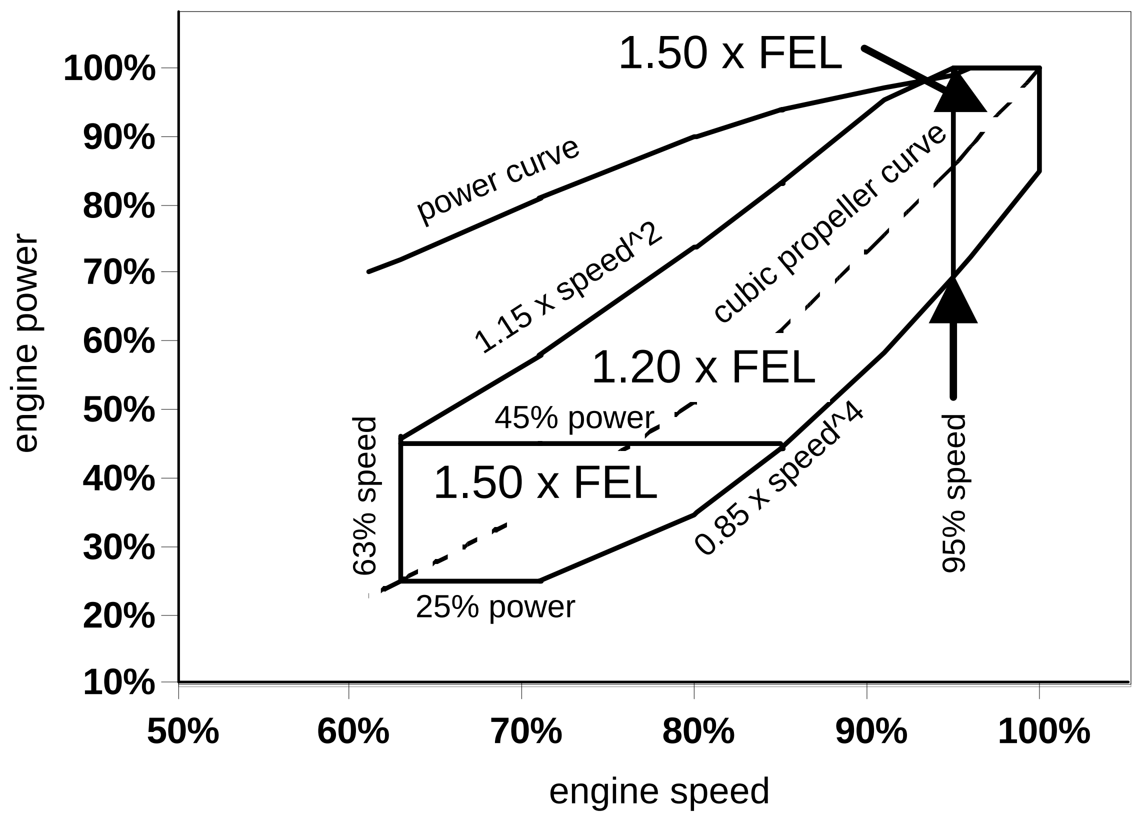
The shape of the NTE zones are based on our understanding of how recreational marine engines are used. Operation at low power is omitted from the NTE zone even though marine engines operate here in use. This omission is because, by definition, brake-specific emissions become very large at low power due to dividing by power values approaching zero.

We believe that the majority of marine engine operation is steady-state. We are therefore including only steady-state operation in the NTE requirements. Also, these are technology-forcing standards, so we expect engines to reduce emissions also under transient operation. If we find that the effectiveness of this program is compromised due to high emissions under transient operation, we will revisit this requirement in the future.

It should be noted that the emissions caps for operation in the NTE zone are based on the weighted emissions over the E5 duty cycle. Because idle emissions are part of these weighted values but not included in the NTE zone, it is likely that emissions in the NTE zone will be less than the weighted average. This alone reduces the stringency of a "not-to-exceed" approach for recreational when compared to commercial marine engines.

For compression-ignition engines, the NTE zone is defined by the maximum power curve, actual propeller curves, and speed and load limits. The E5 duty cycle itself is based on a cubic power curve through the peak power point. For the NTE zone, we define the upper boundary using a speed squared propeller curve passing through the 115% load point at rated speed and the lower boundary using on a speed to the fourth power curve passing through the 85% load point at rated speed. We believe these propeller curves represent the range of propeller curves seen in use.[9] To prevent imposing an unrealistic cap on a brake-specific basis, we are limiting this region to power at or above 25% of rated power and speeds at or above 63% of rated speed. These limits are consistent with mode 4 of the E5 duty cycle. Figure 4.1-1 presents the NTE zone for CI recreational marine engines.

Figure 4.1-1: NTE Zone for Recreational CI Marine Engines



We understand that an engine tested onboard a boat in use may not be operating as the manufacturer intended because the owner may not be using a propeller that is properly matched to the engine and boat. Also, the owner may have a boat that is overloaded and too heavy for the engine. The boundaries in Figure 4.1-1 are intended to contain typical operation of recreational diesel engines and exclude engines which are not used properly. Although the E5 uses a cubic power curve engines generally see some variation in use. These boundaries are consistent with operational data we collected.[10]

We are adopting emissions caps for the NTE zone that represent a multiplier times the weighted test result used for certification. Although ideally the engine should meet the certification level throughout the NTE zone, we understand that a cap of 1.00 times the standard is not reasonable, because there is inevitably some variation in emissions over the range of engine operation. This is consistent with the concept of a weighted modal emission test such as the steady-state tests included in this rule.

Consistent with the commercial requirements, we require that CI recreational marine engines must meet a cap of 1.50 times the certified level for HC+NOx, PM, and CO for the speed and power subzone below 45% of rated power and a cap of 1.20 times the certified levels at or above

45% of rated power. However, we are including an additional subzone, when compared with the commercial NTE zone, at speeds greater than 95% of rated. We are adopting a cap of 1.50 times the certified levels for this subzone. Our purpose for this additional subzone is to address the typical recreational design for higher rated power. This power is needed to ensure that the engine can bring the boat to plane.

We based the caps both on emissions data collected on the assumed propeller curve and on data collected from a recreational marine diesel engine over a wide range of steady-state operation. All of this data is cited earlier in this chapter. The data in Figures 4.1-2 through 4.1-4 show that, within the range of in-use testing points, HC+NOx and PM are generally well below the E5 weighted averages. This is likely due to the effects of emissions at idle. For all of these engines, modal CO results were below the standard. None of these engines are calibrated for emissions control.

Figure 4.1-2: Mode/E5 Average HC+NOx

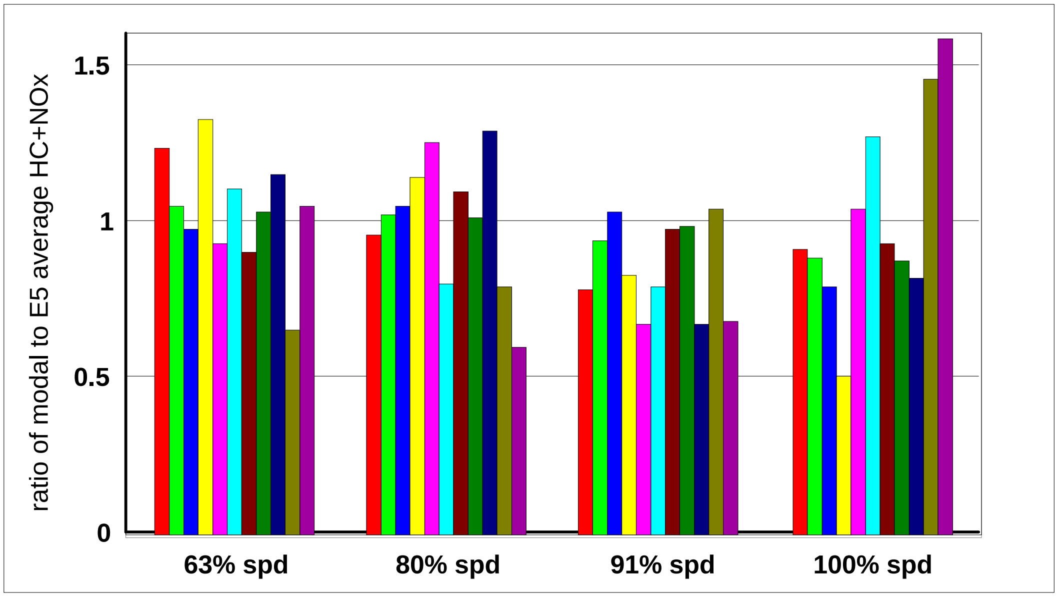


Figure 4.1-3: Mode/E5 Average PM

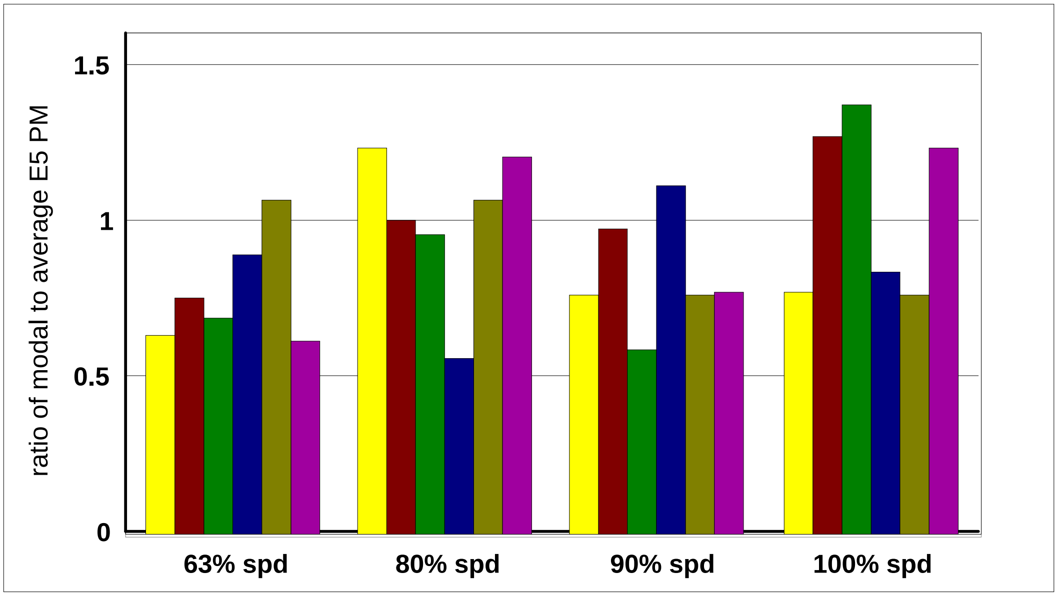
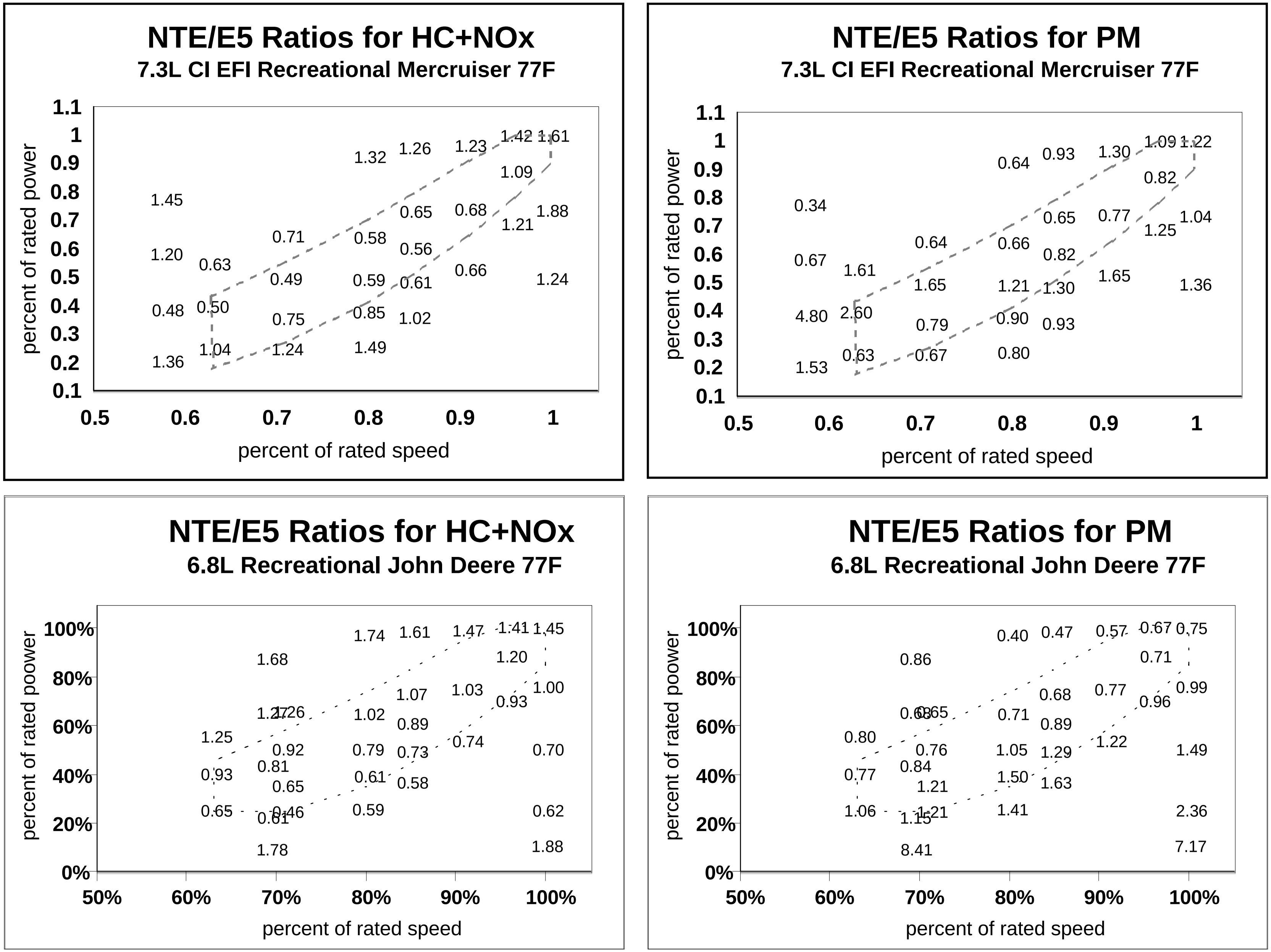


Figure 4.1-4: Ratio of Modal Emissions to E5 Cycle For Two Engines Tested Throughout NTE Zone



4.1.3.2.2 Ambient conditions during testing

Variations in ambient conditions can affect emissions from a marine engine. Such conditions include air temperature, humidity, and (especially for diesels) water temperature. We are applying the same ranges for these variables that apply to commercial marine engine. Within the ranges, no corrections can be made for emissions. Outside of the ranges, emissions can be corrected back to the nearest edge of the range. The ambient variable ranges are:

intake air temperature	13-35°C (55-95°F)
intake air humidity	7.1-10.7 g water/kg dry air (50-75 grains/lb. dry air)
ambient water temperature	5-27°C (41-80°F)

The air temperature and humidity ranges are consistent with those developed for NTE testing of highway heavy-duty diesel engines. The air temperature ranges were based on temperatures seen during ozone NAAQS exceedances.[11] For NTE testing in which the air temperature or humidity is outside of the range, emissions may be corrected back to the air temperature or humidity range. These corrections must be consistent with the equations in Title 40 of the Code of Federal Regulations (CFR), except that these equations correct to 25°C and 10.7 grams per kilogram of dry air, while corrections associated with the NTE testing shall be to the nearest outside edge of the specified ranges. For instance, if the temperature were higher than 35˚C, a temperature correction factor may be applied to the emissions results to determine what the emissions would be at 35˚C.

For marine engines using aftercooling, we believe the charge air temperature is essentially insensitive to ambient air temperature compared to the cooling effect of the aftercooler. SwRI tested this theory and found that when the ambient air temperature was increased from 21.9 to 32.2°C, the cooling water to the aftercooler of a diesel marine engine only had to be reduced by 0.5°C to maintain a constant charge air temperature.[12] According to the CFR correction factor, there is only a ±3% variation in NOx in the NTE humidity range.

Naturally aspirated engines should be more sensitive to intake air temperature because the temperature affects the density of the air into the engine. Therefore, high temperatures can limit the amount of air drawn into the cylinder. Our understanding is that many engines operate in and draw air from small engine compartments. This suggests that any naturally aspirated recreational engines used today are already designed to operate with high intake air temperatures. In any case, we do not believe that manufacturers will use naturally aspirated marine engines to meet the new standards.

Ambient water temperature also may affect emissions due to its impact on engine and charge air cooling. We based the water temperature range on temperatures that marine engines experience in the U.S. in use. Although marine engines experience water temperatures near freezing, we don't believe that additional emission control will be gained by lowering the minimum water temperature below 5°C. At this time, we aren't aware of an established correction factor for ambient water temperature. For this reason, NTE zone testing must be within the specified ambient water temperature range.

We don't think that the range of ambient water temperatures discussed above will have a significant effect on the stringency of the NTE requirements, even for aftercooled engines. Following the normal engine test practice recommended by SAE for aftercooled engines, the cooling water temperature would be set to 25±5°C.[13] This upper portion of the NTE temperature range is within the range suggested by SAE for engine testing. For lower temperatures, manufacturers can use a thermostat or other temperature regulating device to ensure that the charge air is not overcooled. In addition, the SAE practice presents data from four aftercooled diesel engines on the effects of cooling medium temperature on emissions. For every 5°C increase in temperature, HC decreases 1.8%, NOx increases 0.6%, and PM increases 0.1%.

We are aware that many marine engines are designed for operation in a given climate. For instance, recreational vessels operated in Seattle don't need to be designed for 27°C water temperatures. For situations such as this, manufacturers may petition for the appropriate temperature ranges associated with the NTE zone for a specific engine design. In addition, we understand there are times when emission control may need to be compromised for startability or safety. Manufacturers are not responsible for the NTE requirements under start-up conditions. In addition, manufacturers may petition to be exempt from emission control under specified extreme conditions such as engine overheating where emissions may increase under the engine-protection strategy.

4.1.3.3 Emissions Sampling

Aside from the duty cycle, the test procedures for marine engines are similar to those for land-based nonroad engines. However, there are a few other aspects of marine engine testing that need to be considered. Most recreational marine engines mix cooling water into the exhaust. This exhaust cooling is generally done to keep surface temperatures low for safety reasons and to tune the exhaust for performance and noise. Because the exhaust must be dry for dilute emission sampling, the cooling water must be routed away from the exhaust in a test engine.

Even though many marine engines exhaust their emissions directly into the water, we base our test procedures and associated standards on the emissions levels in the "dry" exhaust. Relatively little is known about water scrubbing of emissions. We must therefore consider all pollutants out of the engine to be a risk to public health. Additionally, we are not aware of a repeatable laboratory test procedure for measuring "wet" emissions. This sort of testing is nearly impossible from a vessel in-use. Finally, a large share of the emissions from this category come from large engines which emit their exhaust directly to the atmosphere.

The established method for sampling emissions is through the use of full dilution sampling. However, for larger engines the exhaust flows become so large that conventional dilute testing requires a very large and costly dilution tunnel. One option for these engines is to use a partial dilute sampling method in which only a portion of the exhaust is sampled. It is important that the partial sample be representative of the total exhaust flow. The total flow of exhaust can be determined by measuring fuel flow and balancing the carbon atoms in and out of the engine. For guidance on shipboard testing, the MARPOL NOx Technical Code specifies analytical instruments, test procedures, and data reduction techniques for performing test-bed and in-use emission measurements.[14] Partial dilution sampling methods can provide accurate steady-state measurements and show great promise for measuring transient emissions in the near future. We intend to pursue development of this method and put it in place prior to the date that the standards in this final rule become enforceable.

Pulling a marine engine from a boat and bringing it to a laboratory for testing could be burdensome. For this reason, we may perform in-use confirmatory testing onboard a boat. Our goal would be to perform the same sort of testing as for the laboratory. However, engines tested in a boat are not likely to operate exactly on the assumed propeller curve. For this reason, emissions measured within the NTE zone must meet the subzone caps based on the certified level during onboard testing. To facilitate onboard testing, manufacturers must provide a location with a threaded tap where a sampling probe may be inserted. This location must be upstream of where the water and exhaust mix at a location where the exhaust gases could be expected to be the most homogeneous.

There are several portable sampling systems on the market that, if used carefully, can give fairly accurate results for onboard testing. Engine speed can be monitored directly, but load may have to be determined indirectly. For engines operating at a constant speed, it should be relatively easy to set the engine to the points specified in the duty cycles.

4.1.3.4 Test Fuel Specifications

We are applying the recently finalized test fuel specifications for commercial marine engines to recreational marine diesel engines. These fuel specifications are similar to land-based nonroad fuel with a change in the sulfur content upper limit from 0.4 to 0.8 weight-percent (wt%). We believe this will simplify development and certification burdens for marine engines that are developed from land-based counterparts. This test fuel has a sulfur specification range of 0.03 to 0.80 wt%, which covers the range of sulfur levels observed for most in-use fuels. Manufacturers will be able to test using any fuel within this range for the purposes of certification. Thus, they will be able to harmonize their marine test fuel with U.S. highway (<0.05 wt%) and nonroad (0.03 to 0.40 wt%), and European testing (0.1 to 0.2 wt%).

The intent of these test fuel specifications is to ensure that engine manufacturers design their engines for the full range of typical fuels used by Category 1 marine engines in use. Because the technological feasibility of the new emission standards is based on fuel with up to 0.4 wt% sulfur, any testing done using fuel with a sulfur content above 0.4 wt% would be done with an allowance to adjust the measured PM emissions to the level corresponding with a test using fuel with 0.4 wt% sulfur. We do not expect the sulfur content to have a large impact on PM emissions because only about 2 percent of the sulfur in the fuel is converted to direct sulfate PM.[15]

The full range of test fuel specifications are presented in Table 4.1-3. Because testing conducted by us is limited to the test fuel specifications, it is important that the test fuel be representative of in-use fuels.

Table 4.1-3: Recreational Marine Diesel Test Fuel Specifications

Item	Procedure (ASTM)	Value (Type 2-D)
Initial Boiling Point, °C	D86-90	171-204
10% point, °C	D86-90	204-238
50% point, °C	D86-90	243-282
90% point, °C	D86-90	293-332
End Point, °C	D86-90	321-366
Cetane	D613-86	40-48
Gravity, API	D287-92	32-37
Total Sulfur, % mass	D129-21 or D2622-92	0.03-0.80
Aromatics, % volume	D1319-89 or D5186-91	10 minimum
Paraffins, Napthenes, Olefins	D1319-89	remainder
Flashpoint, °C	D93-90	54 minimum
Viscosity @ 38 °C, centistokes	D445-88	2.0-3.2

4.1.4 Impacts on Noise, Energy, and Safety

The Clean Air Act requires EPA to consider potential impacts on noise, energy, and safety when establishing the feasibility of emission standards for CI recreational marine engines.

One important source of noise in diesel combustion is the sound associated with the combustion event itself. When a premixed charge of fuel and air ignites, the very rapid combustion leads to a sharp increase in pressure, which is easily heard and recognized as the characteristic sound of a diesel engine. The conditions that lead to high noise levels also cause high levels of NOx formation. Fuel injection changes and other NOx control strategies therefore typically reduce engine noise, sometimes dramatically.

The impact of the new emission standards on energy is measured by the effect on fuel consumption from complying engines. Many of the marine engine manufacturers are expected to retard engine timing which increases fuel consumption somewhat. Most of the other technology changes anticipated in response to the new standards, however, have the potential to reduce fuel consumption as well as emissions. Redesigning combustion chambers, incorporating improved fuel injection systems, and introducing electronic controls provide the engine designer with powerful tools for improving fuel efficiency while simultaneously controlling emission formation. To the extent that manufacturers add aftercooling to non aftercooled engines and shift from jacket-water aftercooling to raw-water aftercooling, there will be a marked improvement in fuel-efficiency. Manufacturers of highway diesel engines have been able to steadily improve fuel efficiency even as new emission standards required significantly reduced emissions.

There are no known safety issues associated with the new emission standards. Marine engine manufacturers will likely use only proven technology that is currently used in other engines such as nonroad land-based diesel applications, locomotives, and diesel trucks.

4.2 Large Industrial SI Engines

This category of engines generally includes all nonrecreational land-based spark-ignition engines rated above 19 kW that are not installed in motor vehicles or stationary applications. In an earlier memorandum, we described the rationale for developing emission measurement procedures for transient and off-cycle engine operation.[16] Information from that memorandum is not repeated here, except to the extent that it supports decisions about the selecting the numerical emission standards.

The emission standards for Large SI engines are listed in the Executive Summary. The following paragraphs summarize the data and rationale supporting the standards.

4.2.1 2004 Standards

Engine manufacturers are currently developing technologies and calibrations to meet the 2004 standards that apply in California. We expect manufacturers to rely on electronically controlled, closed-loop fuel systems and three-way catalysts to meet those emission standards. As described below, emission data show that water-cooled engines can readily meet the California ARB standards (3 g/hp-hr NMHC+NOx; 37 g/hp-hr CO).

Manufacturers will have just over one year to prepare engines for nationwide sales starting in 2004. Implementing new standards with such a short lead time is only possible because manufacturers have been aware of their need to comply with the California ARB standards as well as our proposal to implement those standards nationwide. With no need to further modify engine designs, manufacturers should have time before 2004 to plan for increasing production volume for nationwide sale of engines that can meet the 2004 California ARB standards.

Adopting standards starting in 2004 allows us to align near-term requirements with those adopted by California ARB. This also provides early emission reductions and gives manufacturers the opportunity to amortize their costs over a broader sales volume before investing in the changes needed to address the long-term standards described below.

4.2.2 2007 Standards

The 2004 standards described above will reduce emissions from Large SI engines, but we believe these levels don’t fulfill the requirement to adopt standards achieving the “greatest degree of reduction achievable” from these engines in the long term. With additional time to optimize designs to better control emissions, manufacturers can optimize their designs to reduce emissions below the levels required by the 2004 standards. We are also adopting new procedures for measuring emissions starting in 2007, which will require further efforts to more carefully design and calibrate emission-control systems to achieve in-use emission reductions. The following discussion explains why we believe the 2007 emission standards are feasible.

The biggest uncertainty in adopting emission standards for Large SI engines was the degree to which emission-control systems deteriorate with age. While three-way catalysts and closed-loop fueling systems have been in place in highway applications for almost 20 years, we needed to collect information showing how these systems hold up under nonroad use. To address this, we participated in an investigative effort with Southwest Research Institute (SwRI), California ARB, and South Coast Air Quality Management District, as described in the memorandum referenced above.[17] The engines selected for testing had been retrofitted with emission-control systems in Spring 1997 after having already run for 5,000 and 12,000 hours. Both engines are in-line four-cylinder models operating on liquefied petroleum gas (LPG)—a 2-liter Mazda engine rated at 32 hp and a 3-liter GM engine rated at 45 hp. The retrofit consisted of a new, conventional three-way catalyst, electronic controls to work with the existing fuel system, and the associated sensors, wiring, and other hardware. The electronic controller allowed only a single adjustment for controlling air-fuel ratios across the range of speed-load combinations.

Laboratory testing consisted of measuring steady-state and transient emission levels, both before and after taking steps to optimize the system for low emissions. While the engines' emission-control systems originally focused on controlling CO emissions, the testing effort focused on simultaneously reducing HC, NOx, and CO emissions. This testing provides a good indication of the capability of these systems to control emissions over an engine's full useful life. The testing also shows the degree to which transient emissions are higher than steady-state emission levels for Large SI engine operation. Finally, the testing shows how emission levels vary for different engine operating modes. Emission testing included engine operation at a wide range of steady-state operating points and further engine operation over several different transient duty cycles. Much of the emissions variability at different speeds and loads can be attributed to the basic design of the controller, which has a single, global calibration setting. This data showing the variability of emissions is necessary to support the field-testing emission standards, as described further below.

4.2.2.1. Steady-state testing results

Testing results from the aged engines at SwRI showed very good emission control capability over the full useful life. Test results with emission control hardware on the aged engines lead to the conclusion that the systems operated with relatively stable emission levels over the several thousand hours. As shown in Table 4.2-1, the emission levels measured by SwRI are consistent with results from a wide variety of measurements on other engines. The data listed in the table includes only LPG-fueled engines. See Section 4.2.2.6 for a discussion of gasoline-fueled engines.

Table 4.2-1
Steady-State Emission Results from LPG-fueled Engines

Test engine	HC+NOx* g/hp-hr	CO g/hp-hr	Notes**
Mazda 2L[18]	0.51	3.25	4,000 hours, add-on retrofit
GM 3L	0.87	1.84	5,600 hours, add-on retrofit
Engine B	0.22	2.79	250 hours
GFI[19]	0.52 NMHC+NOx	2.23	5,000 hours
Toyota/ECS 2L[20]	1.14	0.78	zero-hour; ISO C1 duty cycle for nonroad diesel engines
GM/Impco 3L[21]	0.26	0.21	zero-hour

*Measurements are THC+NOx, unless otherwise noted.
**Emissions were measured on the ISO C2 duty cycle, unless otherwise noted.

This data set supports emission standards significantly more stringent than the 2004 standards. However, considering the need to focus on transient emission measurements, we believe it is not appropriate to adopt more stringent emission standards based on the steady-state duty cycles. Stringent emission standards based on certain discrete modes of operation may inappropriately constrain manufacturers from controlling emissions across the whole range of engine speeds and loads. We therefore intend to rely more heavily on the transient testing to determine the stringency of the emission-control program.

4.2.2.2 Transient testing results

The SwRI testing is the only known source of information for evaluating the transient emission levels from Large SI engines equipped with emission-control systems. Table 4.2-2 shows the results of this testing. The transient emission levels, though considerably lower than the 2004 standards, are higher than those measured on the steady-state duty cycles. A combination of factors contribute to this. First, these engines are unlikely to maintain precise control of air-fuel ratios during rapid changes in speed or load, resulting in decreased catalyst-conversion efficiency. Also, the transient duty cycle includes operation at engine speeds and loads that have higher steady-state emission levels than the seven modes constituting the C2 duty cycle. Both of these factors also cause uncontrolled emission levels to be higher, so the measured emission levels with the catalyst system still show a substantial reduction in emissions. Additional emission data measured during transient operation is shown in Section 4.2.2.7 for selecting the numerical values for the standards.

Table 4.2-2
Transient Test Results from SwRI Testing

Engine*	Duty Cycle	THC+NOx g/hp-hr	CO g/hp-hr
Mazda	Variable-speed, variable-load	1.1	9.9
	Constant-speed, variable-load	1.5	8.4
GM	Variable-speed, variable-load	1.2	7.0

*Based on the best calibration on the engine operating with an aged catalyst.

4.2.2.3 Off-cycle testing results

Engines operate in the field under both steady-state and transient operation. Although these emission levels are related to some degree, they are measured separately. This section therefore first considers steady-state operation.

Figures 4.2-1 through 4.2-6 show plots of emission levels from the test engines at several different steady-state operating modes. This includes the seven speed-load points in the ISO C2 duty cycle, with many additional test points spread across the engine map to show how emissions vary with engine operation. The plotted emission level shows the emissions at each normalized speed and normalized load point. The 100-percent load points at varying engine speeds form the engine's lug curve, which appears as a straight line because of the normalizing step.

Figure 4.2-1 shows the THC+NOx emissions from the Mazda engine when tested with an aged catalyst. While several points are higher than the 0.51 g/hp-hr level measured on the C2 duty cycle, the highest levels observed from the Mazda engine are around 2.3 g/hp-hr. The highest emissions are generally found at low engine speeds. Emission testing on the Mazda engine with a new catalyst showed very similar results on the C2 duty cycle, so testing was not done over the whole range of steady-state operating points shown in Figure 4.2-1.

CO emissions from the same engine had a similar mix of very low emission points and several higher measurements. The CO levels along the engine's lug curve (100 percent load) range 12 to 22 g/hp-hr, well above the other points, most of which are under 4 g/hp-hr. The corner of the map with high-speed and low-load operation also has a high level of 9 g/hp-hr. These high-emission modes point to the need to address control of air-fuel ratios at these extremes of engine operation.

If CO emissions at these points were an inherent problem associated with these engines, we could take that into account in setting the standard. Figure 4.2-4 shows, however, that the GM engine with the same kind of aged emission-control system had emission levels at most of these points ranging from 0.7 to 4.7 g/hp-hr. The one remaining high point on the GM engine was

11.6 g/hp-hr at full load and low speed. A new high-emission point was 28 g/hp-hr at the lowest measured speed and load. Both of these points are much lower on the same engine with the new catalyst installed (see Figure 4.2-6). These data reinforce the conclusion that adequate development effort will enable manufacturers to achieve broad control of emissions across the engine map.

Figure 4.2-3 shows the THC+NOx emissions from the GM engine when tested with the aged catalyst. Emission trends across the engine map are similar to those from the Mazda engine, with somewhat higher low-speed emission levels between 2.3 and 4.4 g/hp-hr at various points. Operation on the new catalyst shows a significant shifting of high and low emission levels at low-speed operation, but the general observation is that the highest emission levels disappear, with 2.3 g/hp-hr being again the highest observed emission level over the engine map (see Figure 4.2-5).

Figure 4.2-1

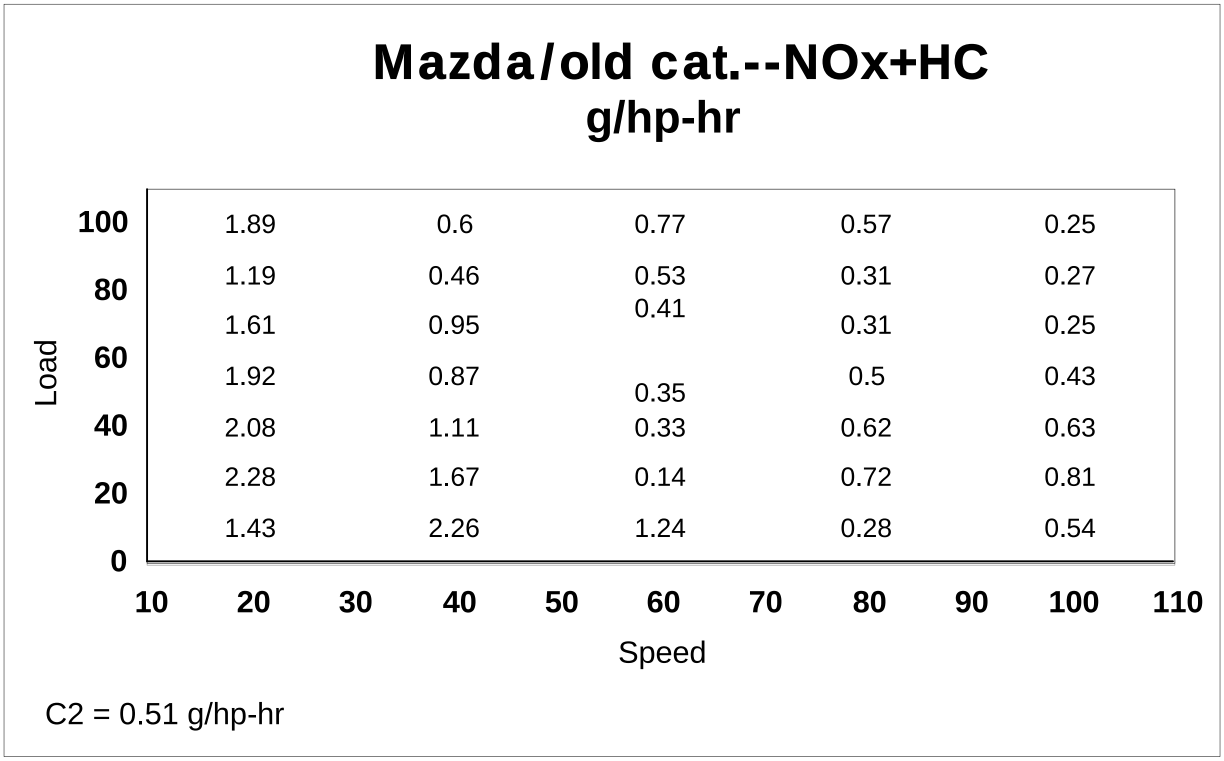


Figure 4.2-2

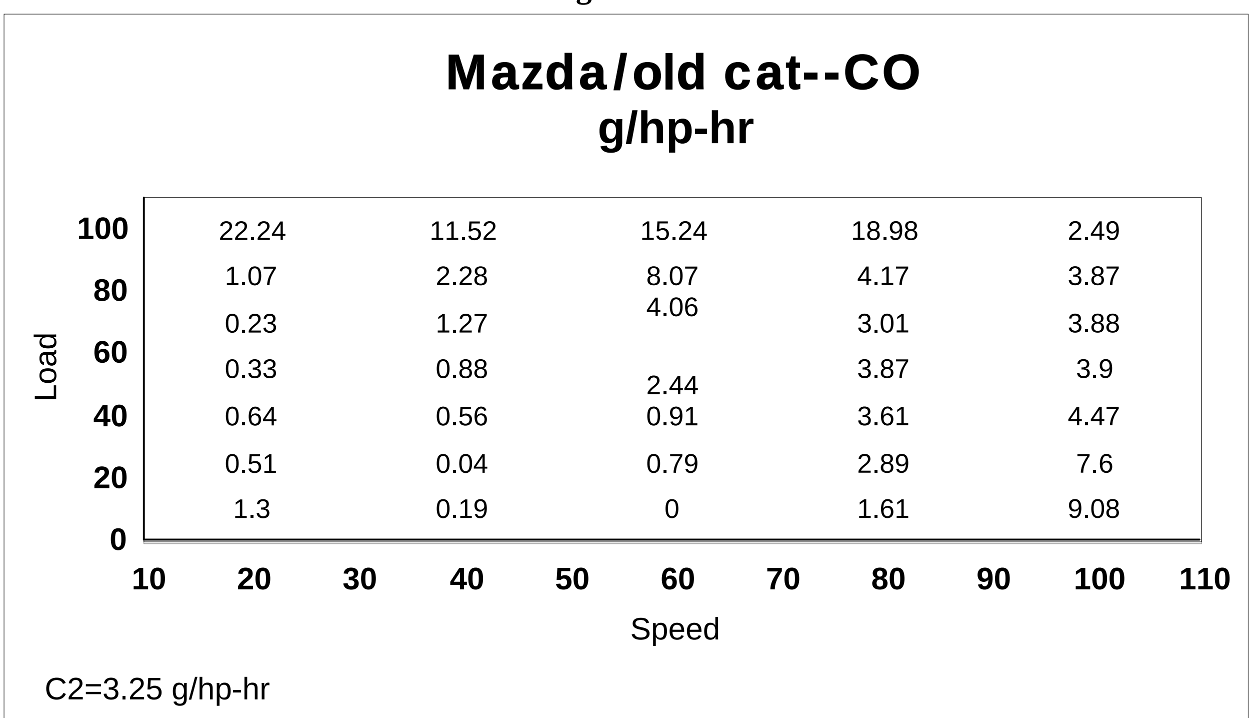


Figure 4.2-3

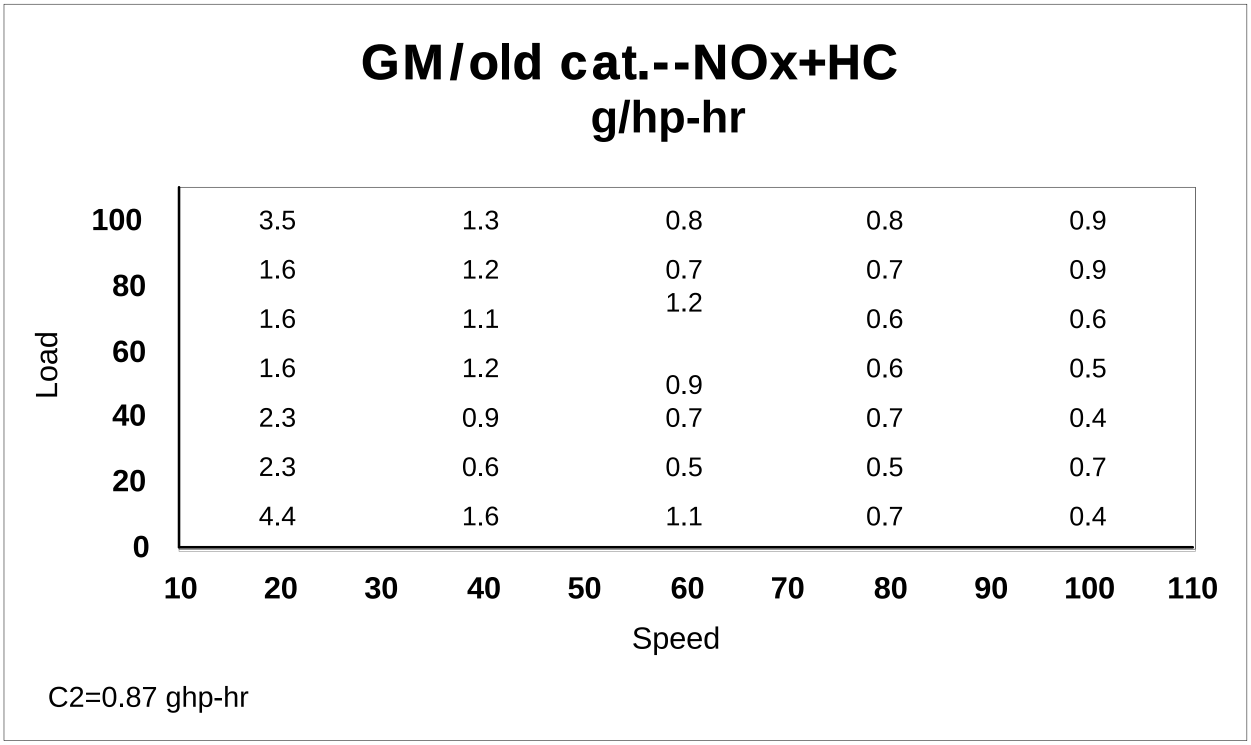


Figure 4.2-4

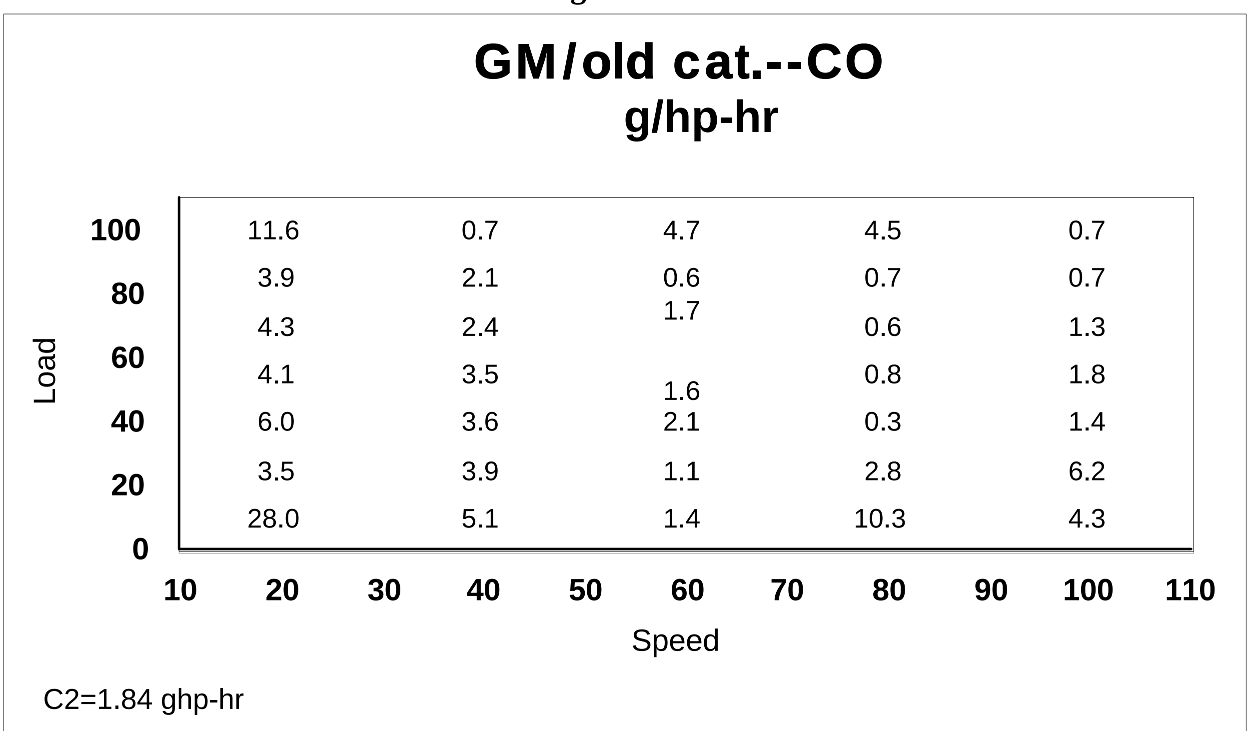


Figure 4.2-5

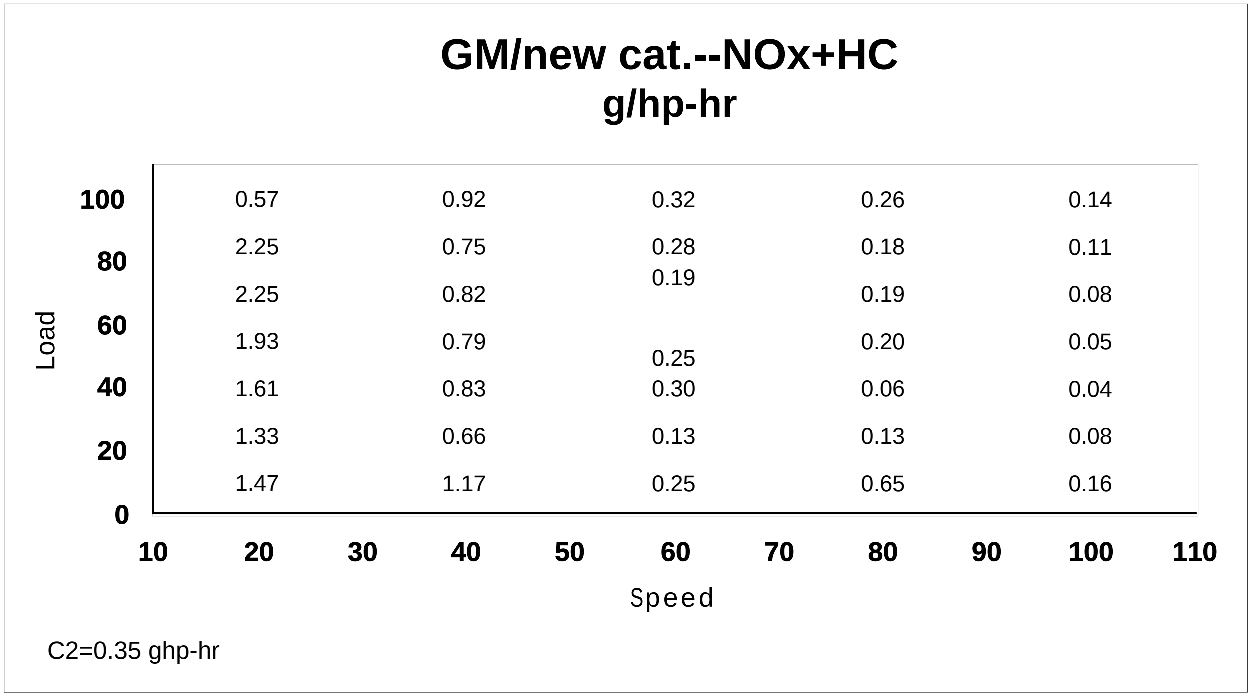
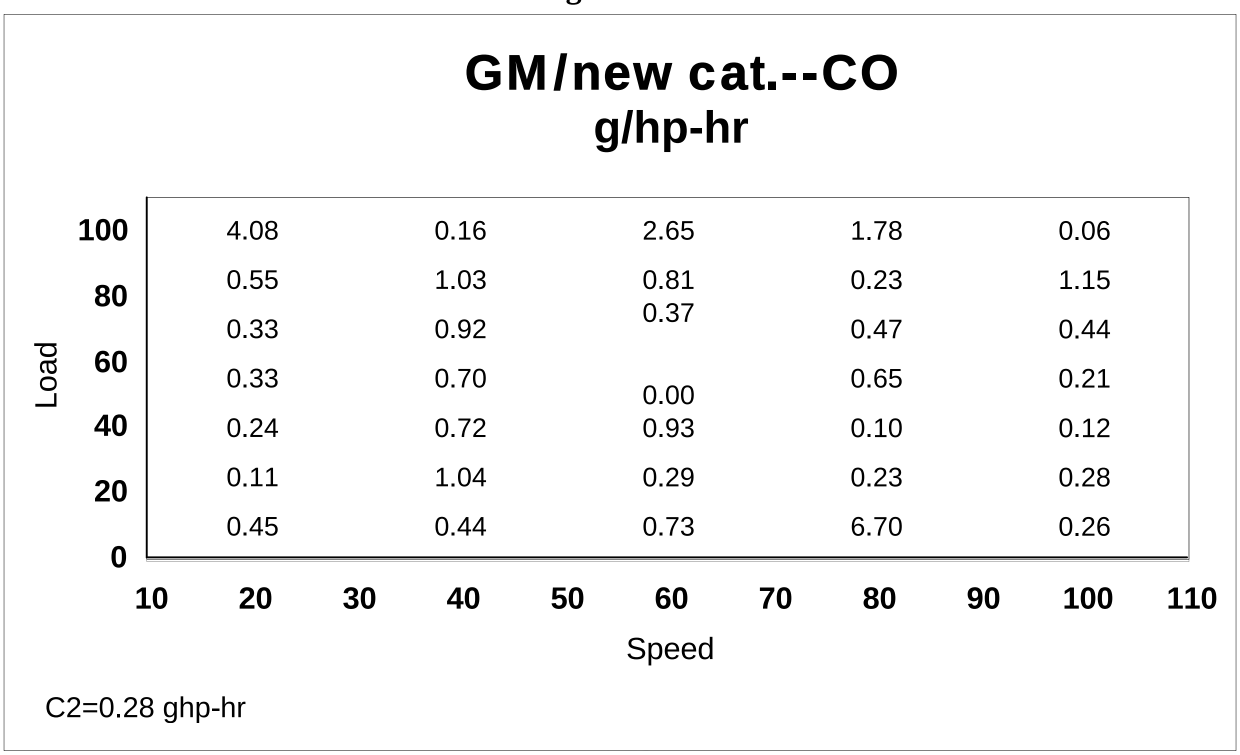


Figure 4.2-6



Field testing will typically also include transient emission measurement. Field-testing measurement may include any segment of normal operation with a two-minute minimum sampling period. This does not include engine starting, extended idling, or other cold-engine operation. Table 4.2-3 shows a wide variety of transient emission levels from the two test engines. While the engines were tested in the laboratory, the results show how emissions vary under normal operation when installed in nonroad equipment. These segments could be considered as valid field-testing measurements to show that an engine meets emission standards in the field when tested in nonroad equipment in which the engines are installed. Several segments included in the table were run with a hot start, which could significantly increase emission levels, depending on how long the engine runs in open loop after starting. This is especially important for CO emissions. Even with varied strategies for soaking and warming up engines, emission levels are generally between 1 and 2 g/hp-hr THC+NOx and between 4 and 13 g/hp-hr CO. Emission levels don't seem to vary dramatically between cycle segments, even where engine operation is significantly different.

Table 4.2-3
Transient Emission Measurements from SwRI Testing

Engine	Test Segment	THC+NOx g/hp-hr	CO, g/hp-hr	Notes
Mazda	"typical" forklift (5 min.)	2.0	5.7	hot start
	"high-transient" forklift (5 min.)	1.3	4.3	hot start
	highway certification test	1.2	4.6	hot start
	backhoe/loader cycle	1.3	9.1	20-minute soak before test
GM	"typical" forklift (5 min.)	1.3	9.5	hot start
	"high-transient" forklift (5 min.)	2.0	12.6	hot start
	highway certification test	1.0	4.4	3-minute warm-up; 2-minute soak
	backhoe/loader cycle	1.0	3.8	3-minute warm-up; 2-minute soak

4.2.2.4 Ambient conditions

While certification testing involves engine operation in a controlled environment, engines operate in conditions of widely varying temperature, pressure, and humidity. To take this into account, we are broadening the range of acceptable ambient conditions for field-testing measurements. Field-testing emission measurements must occur with ambient temperatures between 13° and 35° C (55° and 95° F), and with ambient pressures between 600 and 775 millimeters of mercury (which should cover almost all normal pressures from sea level to 7,000 feet above sea level). Tests will be considered valid regardless of humidity levels. This allows testing under a wider range of conditions in addition to helping ensure that engines are able to control emissions under the whole range of conditions under which they operate.

The SwRI test data published here are based on testing under laboratory conditions typical for the test location. Ambient temperatures ranged from 70 to 86° F. Barometric pressures were in a narrow range around 730 mm Hg. Humidity levels ranged from about 4 to 14 g of water per kg dry air, but all emission levels were corrected to a reference condition of 10.7 g/kg. Most testing occurred at humidity levels above 10.7, in which case actual NOx emission levels were up to 7 percent lower than reported by SwRI after correction.. In the driest conditions, measured NOx emission levels were up to 10 percent higher than reported. The field-testing standards take into account the possibility of a humidity effect of increasing NOx emissions. We are not aware of any reasons that varying ambient temperatures or pressures will have a significant effect on emission levels from spark-ignition engines.

4.2.2.5 Durability of Emission-Control Systems

SwRI tested engines that had already operated for the full useful life period with functioning emission-control systems. Before being retrofitted with catalysts and electronic fuel systems, these engines had already operated for 5,000 and 12,000 hours, respectively. The tested systems therefore provide very helpful information to show the capability of the anticipated emission-control technologies to function over a lifetime of normal in-use operation.

The testing effort required selection, testing, and re-calibration of installed emission-control systems that were not designed specifically to meet emission standards. These systems were therefore not necessarily designed for simultaneously controlling NOx, HC, and CO emissions, for lasting 5,000 hours or longer, or for performing effectively under all conditions and all types of operation that may occur. The testing effort therefore included a variety of judgments, and adjustments to evaluate the emission-control capability of the installed hardware. This effort highlighted several lessons that should help manufacturers design and produce durable systems.

Selecting engines from the field provided the first insights into the functionality of these systems. Tailpipe ppm measurements showed that several engines had catalysts that were inactive (or nearly inactive). These units were found to have loose catalyst material inside the housing, which led to a significant loss of the working volume of the catalyst and exhaust flow bypassing the catalyst material. Dimensional measurements showed that this resulted from a straightforward production error of improperly assembling the catalyst inside the shell.[22] This is not an inherent problem with catalyst production and is easily addressed with automated or more careful manual production processes. The catalyst from the GM engine selected for testing had also lost some of its structural integrity. Almost 20 percent of the working volume of the catalyst had disappeared. This catalyst was properly re-assembled with its reduced volume for further testing. This experience underscores the need for effective quality-control procedures in assembling catalysts.

Substituting a new catalyst on the aged system allowed emission measurements that help us estimate how much the catalysts degraded over time. This assessment is rather approximate, since we have no information about the zero-hour emissions performance of that exact catalyst. The new catalysts, which were produced about three years later under the same part numbers and nominal characteristics, generally performed in a way that was consistent with the aged catalysts. Not surprisingly, the catalyst with the reduced working volume showed a higher rate of deterioration than the intact catalyst. Both units, however, showed very stable control of NOx and HC emissions. CO deterioration rates were generally higher, but the degree of observed deterioration was very dependent on the particular duty cycle and calibration for a given set of emission measurements.

Measured emission levels from the aged catalysts shows what degree of conversion efficiency is possible for each pollutant after several thousand hours of operation. The emission data from the new catalysts suggest that manufacturers probably need to target low enough zero-hour CO emission levels to account for significant deterioration. The data also show that catalyst size is an important factor in addressing full-life emission control. The nominal sizes of the catalysts on the test engines were between 50 and 55 percent of total engine displacement. The cost analysis in Chapter 5 is based on initial compliance with a catalyst sized at 60 percent of total engine displacement. We expect manufacturers to reduce catalyst size as much as possible to reduce costs without risking the possibility of high in-use emissions.

Another important issue relates to degradation associated with fuel impurities, potential lack of maintenance, and wear of oxygen sensors. Fuel system components in LPG systems are prone to fuel deposits, primarily from condensation of heavy hydrocarbon constituents in the fuel. The vaporizer and mixer on the test engines showed a typical degree of fuel deposits from LPG operation. The vaporizer remained in the as-received condition for all emission measurements throughout the test program. Emission tests before and after cleaning the mixer give an indication of how much the deposits affect the ability of the closed-loop fueling system to keep the engine at stoichiometry. For the GM engine operating with the aged catalyst, the combined steps of cleaning the mixer and replacing the oxygen sensor improved overall catalyst efficiency on the C2 duty cycle from 55 to 61 percent for NOx. CO conversion efficiency improved only slightly. For the Mazda engine, the single step of cleaning the mixer slightly *decreased* average catalyst efficiency on the C2 duty cycle for NOx emissions; HC and CO conversion efficiency improved a small amount (see Table 4.2-4). Engines operating with new catalysts showed the same general patterns. These data show that closed-loop fueling systems can be relatively tolerant of problems related to fuel impurities.

Table 4.2-4
Average C2 Catalyst Conversion Efficiencies Before and After Maintenance

Engine	Pollutant	OLD CATALYST		NEW CATALYST	
		before maintenance	after maintenance	before maintenance	after maintenance
GM	NOx	54.7%	61.1%	45.6%	56.1%
	CO	96.3%	98.1%	99.3%	99.5%
	HC	93.8%	93.6%	93.6%	93.7%
Mazda	NOx	62.3%	61.5%	60.3%	60.1%
	CO	96.9%	98.9%	99.6%	99.6%
	HC	86.9%	93.2%	86.2%	94.3%

Manufacturers may nevertheless be concerned that some in-use operation can cause fuel deposits that exceed the fuel system's compensating ability to maintain correct air-fuel ratios. Two technologies are available to address this concern. First, the required diagnostic systems inform the operator if fuel-quality problems are severe enough to prevent the engine from operating at stoichiometry. A straightforward cleaning step would restore the fuel system to normal operation. Manufacturers may also be able to monitor mixer performance directly to detect problems with fuel deposits, rather than depending on air-fuel ratios as a secondary indicator. In any case, by informing the operator of the need for maintenance, the diagnostic system reduces the chance that the manufacturer will find high in-use emissions that result from fuel deposits.

The second technology to consider is designed to prevent fuel deposits from forming. A commercially available thermostat regulates fuel temperatures to avoid any high-temperature or low-temperature effects. In addition, some industry participants have made the general observation that some engine models are more susceptible to fuel deposits than others, suggesting that there may be other engine-design parameters that may help prevent these problems.

Maintaining the integrity of the exhaust system another basic but essential element of keeping control of air-fuel ratios. Any leaks in the exhaust pipe between the exhaust valves and the oxygen sensor would allow dilution air into the exhaust stream. The extra oxygen from the dilution air would cause the oxygen sensor to signal a need to run at a air-fuel ratio that is richer than optimal. If an exhaust leak occurs between the oxygen sensor and the catalyst, the engine will run at the correct air-fuel ratio, but the extra oxygen would affect catalyst conversion efficiencies. As evidenced by the test engines, manufacturers can select materials with sufficient quality to prevent exhaust leaks over the useful life of the engine.

4.2.2.7 Emission standards

4.2.2.7.1 Technology Basis

Three-way catalyst systems with electronic, closed-loop fuel systems have a great potential to reduce emissions from Large SI engines. We believe these technologies are capable of the greatest degree of emission reduction achievable from these engines in the projected time frame, considering the various statutory factors. In particular, we are not basing the emission standards on the emission-control capability from any of the following technologies.

- Spark timing
- Combustion-chamber redesign
- Gaseous fuel injection
- Exhaust gas recirculation

Incorporating these technologies with new engines could further reduce emissions; however, Large SI engine manufacturers typically produce 10,000 to 15,000 units annually, which limits the resources available for an extensive development program. Considering the limited development budgets for improving these engines, we believe it is more important to make a robust design with basic emission-control hardware than to achieve very low emission levels with complex hardware at a small number of steady-state test modes. Even without these additional technologies, we anticipate that manufacturers will be able to reduce emissions by about 90 percent from uncontrolled levels. Further optimizing an engine with a full set of emission-control hardware while meeting transient and field-testing emission standards is more of a burden than Large SI manufacturers can bear in the projected time frame. Manufacturers producing new engines may find it best to use some of these supplemental technologies to achieve the desired level of emission control and performance at an acceptable cost.

4.2.2.7.2 Duty-cycle emission standards

Given the control technology, as described above, there is a need to select emission standards that balance the tradeoff between NOx and CO emissions. Both NOx and CO vary with changing air-fuel ratios, but in an inverse relationship. This is especially important considering the degree to which these engines are used in enclosed areas.

Commenters representing states and environmental groups stressed the need to control HC+NOx emissions to address concerns for meeting ambient air quality standards for ozone. We are accordingly setting an HC+NOx emission standard of 2.0 g/hp-hr (2.7 g/kW-hr), which is somewhat more stringent than the proposed standard. We are adopting a slightly higher CO emission standard than proposed, which reflects the tradeoff between NOx and CO emissions. Further, we are adopting provisions that will encourage manufacturers to reduce HC+NOx even further by allowing higher CO levels where a manufacturer certifies to lower HC+NOx levels. Under this approach, customers desiring to protect workers or others in close proximity to the engines can choose engine models that offer the maximum control of CO emissions. Conversely, if individual exposure to CO emissions is less of a concern, manufacturers have a strong incentive to maximize control of HC+NOx emissions.

Table 4.2-5 shows the range of measured emission values from the engines tested with optimized emission controls. In general, the engines with higher CO values and lower HC+NOx values were calibrated with slightly richer air-fuel ratios, with all other engine parameters unchanged. The measured emission levels include a variety of duty cycles, but this doesn't seem to affect the observed trends. Also, Table 4.2-5 notes the length of time the engine was turned off before starting the transient duty cycle. All the data points shown are from measurements with the aged catalysts. Several measurements with the new catalyst showed that engines were able to achieve very low levels of both NOx and CO emissions.

Table 4.2-5
Range of Measured Emission Levels (g/hp-hr)

Engine*	HC	NOx	HC+NOx	CO	Cycle	soak, min.
GM	0.30	3.82	4.12	0.66	Backhoe-loader	4
GM	0.27	4.14	4.41	0.68	Backhoe-loader	2
GM	0.41	5.91	6.32	0.83	Backhoe-loader	20
GM	0.29	5.89	6.18	0.86	Large SI Composite	6
GM	0.27	4.42	4.69	0.87	Highway FTP	3
GM	0.28	5.33	5.61	0.89	Highway FTP	3
Mazda	0.34	0.88	1.22	4.61	Highway FTP	5
Mazda	0.58	0.15	0.73	6.66	Large SI Composite	5
Mazda	0.61	0.19	0.8	6.97	Large SI Composite	5
Mazda	0.66	0.14	0.8	7.5	Large SI Composite	5
Mazda	0.6	0.35	0.95	7.61	Large SI Composite	7
Mazda	0.51	0.7	1.21	7.76	Welder	4

*Both engines operated on LPG for all tests.

Figure 4.2-7 shows an attempt to apply a curve-fit to the data points. Using a log-log relationship as shown yielded an R-square value of 0.93, indicating a relatively good fit to the data. Table 4.2-6 and Figure 4.2-8 show the curve relating CO and HC+NOx emission levels using the mathematical relationship. This involves starting with a set of HC+NOx emission levels, then calculating the corresponding CO emission levels.[t] Finally, both CO and HC+NOx emission levels are increased by 10 percent to account for a compliance margin around the measured data points. These standards apply to all steady-state and transient duty-cycle testing for certification, production-line, and in-use testing.

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[t]While somewhat roundabout mathematically, solving for CO values from the logarithmic equation is most easily done by converting the curve-fit to an equation based on the natural log function. Using logarithm relationships yields the equivalent relationship (in metric units): $(HC+NOx) \times CO^{0.784} = 8.57$ or $CO = (8.57 \div (HC+NOx))^{1.276}$.

Figure 4.2-7

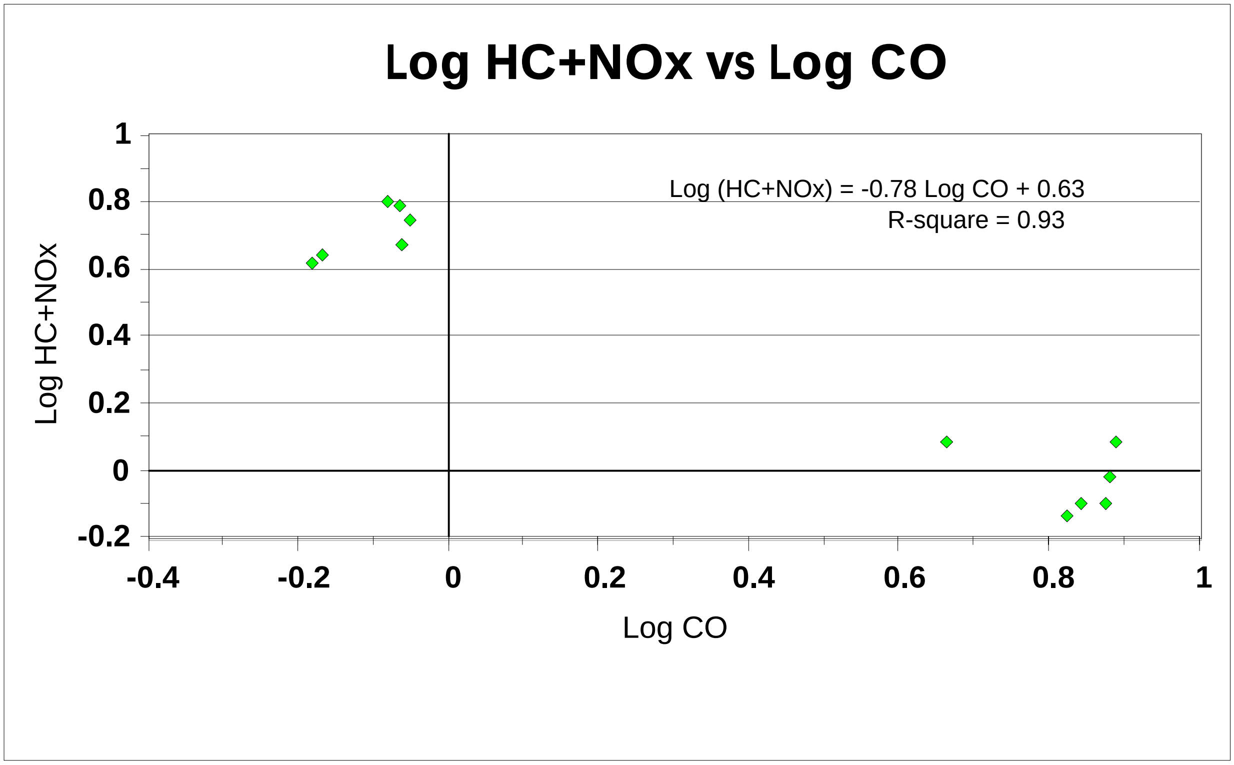
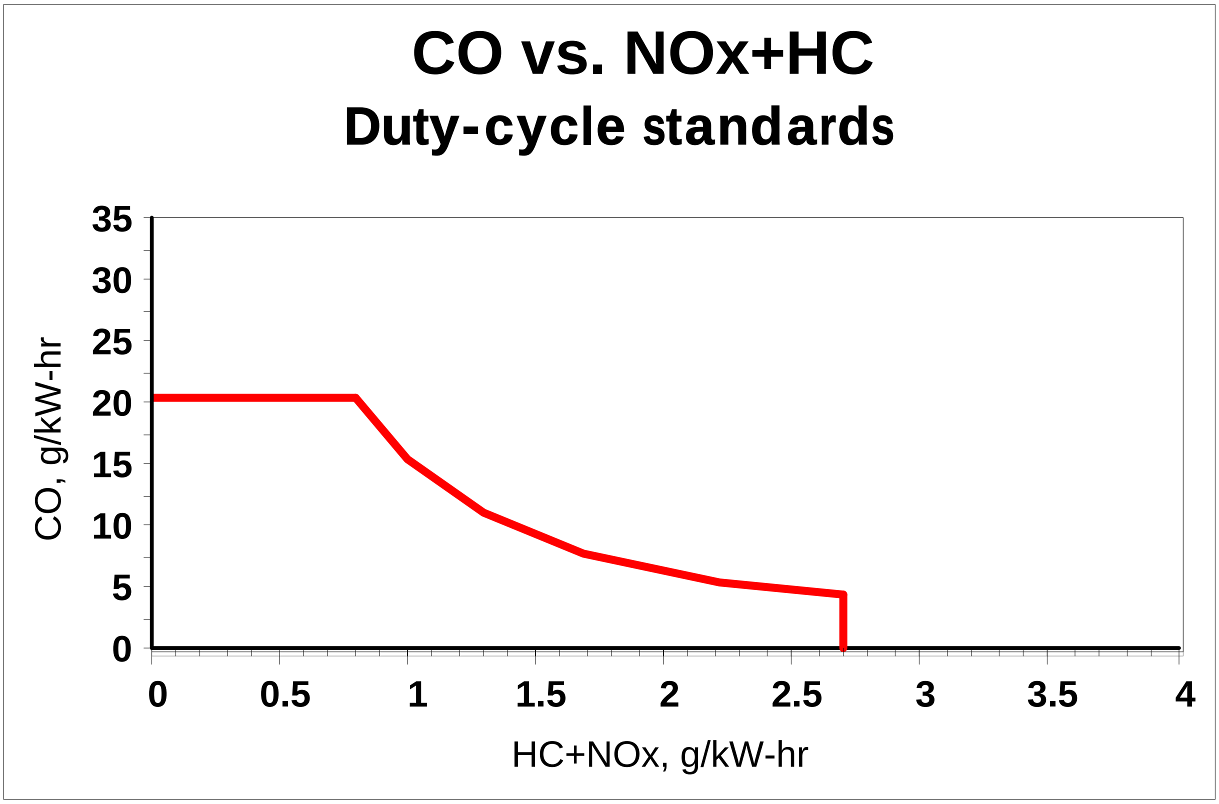


Table 4.2-6
Sample Standards Using the
Optional Duty-cycle Standards(g/kW-hr)

HC+NOx	CO
2.70	4.4
2.20	5.6
1.70	7.9
1.30	11.1
1.00	15.5
0.80	20.6

Figure 4.2-8



We generally set standards by focusing on attaining ambient air quality in broad outdoor areas. The HC+NOx standard of 2.7 g/kW-hr is consistent with this focus and achieves significant reductions in ozone precursor emissions. Moreover, any of the emission levels shown in Table 4.2-6 provide large reductions in CO, NO, and NO_2 to address any concerns for individual exposures.

4.2.2.7.3 Engine protection

The table of standards above does not take into account the fact that some engines are unable to maintain sustained stoichiometric operation at high engine loads. Engines running rich at high load typically continue to have low HC+NOx emissions, but CO emissions increase substantially. However, operation over the transient duty cycle involves very little sustained high-load operation. Table 4.2-7 shows the total time during the 20-minute cycle with engine loads exceeding various thresholds. This alone shows that the standard for testing over the transient duty cycle needs little or no adjustment to account for rich operation under high-load conditions. Delaying rich operation would further ensure that emission-controls continue to function properly while still protecting against overheating. As a result, we don't believe that emission standards for the transient emission test should be adjusted to account for engine-protection strategies.

Table 4.2-7
Evaluation of High-Load Operation Over the Transient Duty Cycle

Torque threshold (percent of maximum at a given speed)	Total time over torque threshold (seconds)	Percent of 20-minute cycle	Average number of seconds during each minute
90%	16	1.3	0.8
85%	23	1.9	1.2
80%	41	3.4	2.0
75%	67	5.6	3.4

The steady-state duty cycles, however, have a fixed weighting to account for emission levels at high load operation. Also, delaying enrichment does not help with steady-state emissions, because emissions are measured only after engine operation and emission levels have stabilized. We are therefore setting a maximum CO level of 31 g/kW-hr during steady-state testing for engines needing protection strategies. This corresponds to the highest CO emission level we are allowing under field-testing standards, as noted in Table 1 and described further below. This less stringent standard would apply to all steady-state testing with the C2 or D2 duty cycles for certification, production-line, or in-use testing. The emission standards described in Table 1 would still apply to these engines when tested over the transient duty-cycle. We are also applying the field-testing standards equally to different engines, regardless of whether or not they are certifying to a less stringent CO emission standard for steady-state testing. This reflects our expectation that engines undergoing normal operation in the field will continue to meet emission standards.

Ford submitted test data with their gasoline engine showing that their emission levels comply with this less stringent CO standard for steady-state testing. For example, with a measured emission level of 23.9 g/kW-hr, they would have roughly a 20-percent compliance margin relative to a standard of 31 g/kW-hr. The proposed curve of candidate emission standards incorporated a 10-percent compliance margin, even though the measured emissions were from aged engines not designed to meet emission standards. Our emission modeling typically incorporates an assumed 20-percent compliance margin for spark-ignition engine emissions.

In addition, as described in the preamble to the final rule, we are adopting a combination of provisions to ensure that manufacturers will take steps to allow enrichment only under exceptional circumstances. This is necessary to ensure that engines in nonroad equipment don’t operate substantially under engine-protection regimes leading to compromised control of emissions.

4.2.2.7.4 Field-testing emission standards

Manufacturers may do testing under the in-use testing program using field-testing procedures. This has the potential to substantially reduce the cost of testing. Setting an emission standard for testing engines in the field requires that we take into account all the variability inherent in testing outside the laboratory. As discussed further below, this includes varying engine operation, and a wider range of ambient conditions, and the potential for less accurate or less precise emission measurements and calculations. Also, while the field-testing standards and procedures are designed for testing engines installed in equipment, engines can also be tested on a dynamometer to simulate what would happen in the field. In this case, extra precautionary steps would be necessary to ensure that the dynamometer testing could be characterized as "normal operation." Also, the less stringent field-testing standards would apply to any simulated field-testing on a dynamometer to take emission-measurement variability into account, as described below.

The SwRI test engines also show that Large SI engines are capable of controlling emissions under the wide range of operation covered by the field-testing provisions. A modest amount of additional development will be necessary to address isolated high-emission points uncovered by the testing. We believe that manufacturers will be able to reduce emissions as needed to meet the 2007 emission standards by spending time improving the precision of their engine calibrations, perhaps upgrading to more sophisticated control software to achieve this. Field testing may also include operation at a wider range of ambient conditions than for certification testing. Selecting emission standards for field testing that correspond with the duty-cycle standards requires consideration of the following factors:

- The data presented above show that emissions vary for different modes of engine operation. Manufacturers will need to spend time addressing high-emission points to ensure that engines are not overly sensitive to operation at certain speeds or loads. The data suggest that spark-ignition engines can be calibrated to improve control at the points with the highest emission rates.
- Established correction factors allow for adjustment to account for varying ambient conditions. Allowing adjustment of up to 10 percent adequately covers any potential increase in emissions resulting from extreme conditions.
- While emission measurements with field-testing equipment allow more flexibility in testing, they are not as precise or as accurate as in the laboratory; the regulations define specifications to limit the error in emission measurements. For most mass-flow and gas analyzer hardware, these tolerance remain quite small. Measurements and calculations for torque values introduce a greater potential for error in determining brake-specific emission levels. The tolerance for onboard torque readings allows for a 15-percent error in understating torque values, which would translate into a 15-percent error in overstating brake-specific emissions.

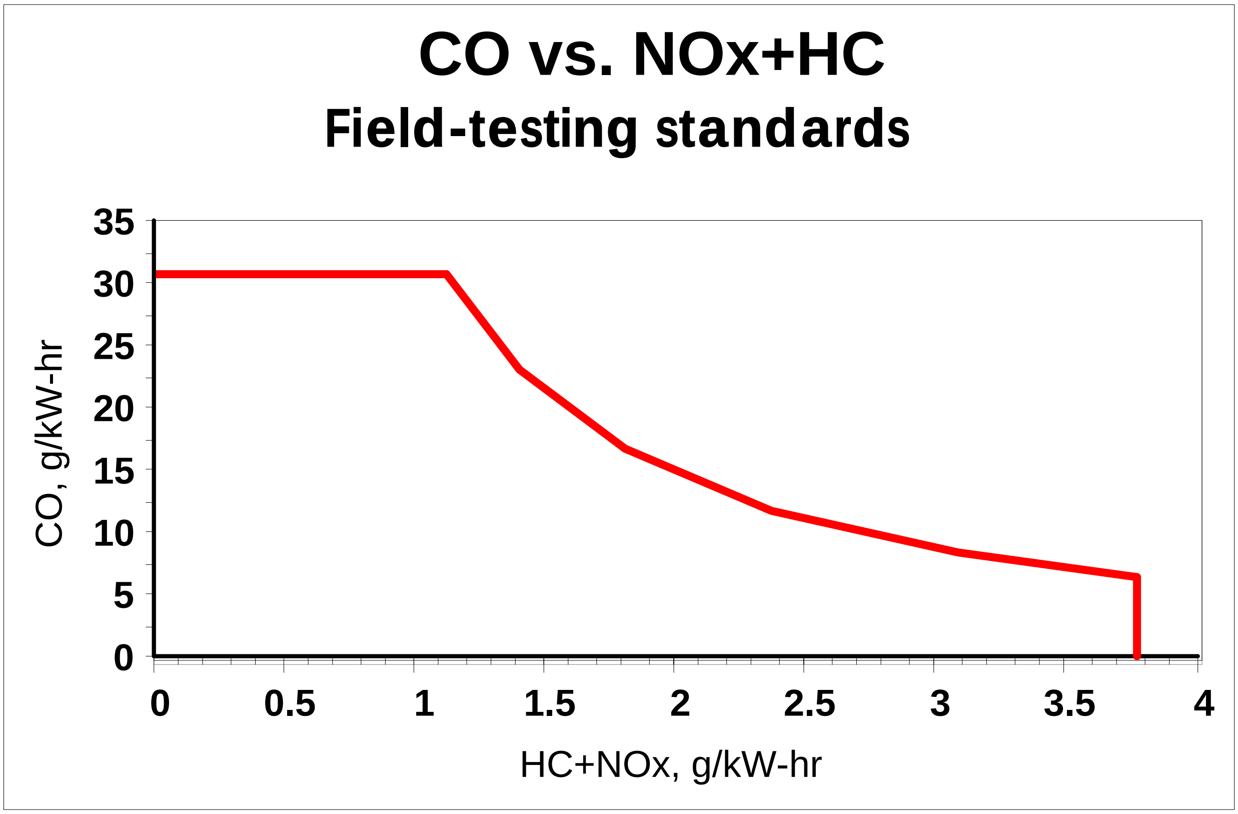
Taking all these factors into account, we believe it is appropriate to allow for a 40-percent increase in HC+NOx emissions relative to the SwRI measured values to account for the factors listed above. CO emissions are generally somewhat more sensitive to varying engine operation, so a 50-percent adjustment is appropriate for CO. The approach for field-testing standard follows the format described for duty-cycle testing. This results in an HC+NOx standard of 3.8 g/kW-hr (2.8 g/hp-hr), with scaled values for the CO standard, as shown in Table 4.2-8 and Figure 4.2-9.

These same numerical field-testing standards apply to natural gas engines. Much like for certification, we are excluding methane measurements from natural gas engines. Since there are currently no portable devices to measure methane (and therefore nonmethane hydrocarbons), the 3.8 g/kW-hr field-testing standard and the values in Table 4.2-8 apply only to NOx emissions for natural gas engines.

Table 4.2-8
Sample Standards Using the
Optional Field-testing Standards(g/kW-hr)

HC+NOx	CO
3.80	6.5
3.10	8.5
2.40	11.7
1.80	16.8
1.40	23.1
1.10	31.0

Figure 4.2-9



4.2.2.7.5 Evaporative emissions

Several manufacturers are currently producing products with pressurized fuel tanks to comply with Underwriters Laboratories specifications. Most fuel tanks in industrial applications are made of a thick-gauge sheet metal or structural steel, so increasing fuel pressures within the anticipated limits poses no risk of bursting or collapsing tanks. For those few applications that use plastic fuel tanks, equipment manufacturers already use or could easily use blow-molded tanks that are also able to withstand substantial pressure buildup. If an exceptional application relies on a fuel tank that must keep internal pressures near ambient levels, a volume-compensating bag would allow for adequate suppression of fuel vapors with minimal pressure buildup.[u]

Testing with pressurized fuel tanks shows emission data related to sealing fuel tanks. The tests included several pressures ranging from 0.5 to 2.25 psi. The 2.25 psi valve was an off-the-shelf automotive fuel cap with a nominal 2 psi pressure relief valve and 0.5 psi vacuum relief valve. For the other pressure settings, we used another automotive cap modified to allow

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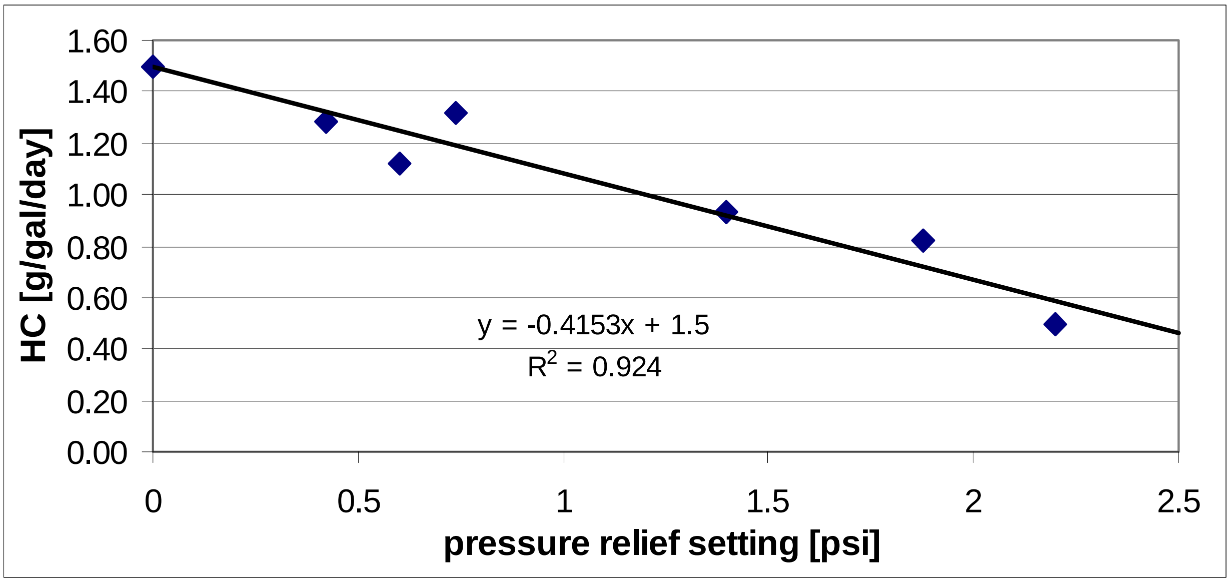
[u] "New Evaporative Control System for Gasoline Tanks," EPA Memorandum from Charles Moulis to Glenn Passavant, March 1, 2001, Docket A-2000-01, document II-B-16.

adjustments to the spring tension in the pressure relief valve. We performed these tests on an aluminum fuel tank to remove the variable of permeation. As shown in Figure 4.2-10, there was a fairly linear relationship between the pressure setting of the valve and the emissions measured over the proposed test procedure, which we would expect based on the theoretical relationships. At 3.5 psi, this relationship extropolates to a value of 0.2 g/gallon/day.

Figure 4.2-10: Effect of Pressure Cap on Diurnal Emissions



4.2.2.7.6 Conclusion

Manufacturers have been developing emission-control technologies to meet the 2004 emission standards since October 1998, when California ARB adopted the same standards. We expect that manufacturers will add three-way catalysts to their engines and use electronic closed-loop fueling systems. These technologies have been available for industrial engines for many years.

The SwRI testing program was based on aged engines and involved no effort to fine-tune air-fuel ratios or emission levels across the engine map. We expect that manufacturers will be able to control emission levels more broadly across the range of engine speeds and loads by improving control of air-fuel ratios at different operating modes. These improvements will reduce both steady-state and transient emission levels. The 2007 emission standards are based directly on the data presented above. The test results therefore show that these Large SI engines are capable of meeting the 2007 emission standards for both steady-state and transient duty cycles. Similarly, the data presented above show how off-cycle emissions vary for engines that have been designed for effective control of air-fuel ratios across the range of normal operation. Here too, the test engines generally had emission levels consistent with the 2007 field-testing standards, with certain limited exceptions as noted above.

The SwRI testing program involved about eight weeks of development effort to characterize and modify two engines to for optimized emissions on the steady-state and transient duty cycles, and for all kinds of off-cycle operation. Both of the test engines had logged several thousand hours of operation using off-the-shelf technologies that have been available for nonroad engines for many years. Several hardware and software adjustments were made to maintain optimal air-fuel ratios for effective control of all pollutants under all operating modes. Some further development effort will be necessary to address the few isolated modes with high emission levels, as described earlier in this section. Manufacturers may save development time by upgrading to the modestly more expensive controller with independent air-fuel control capability in different speed-load zones. This would achieve the same result, but would potentially reduce the cost of meeting the standards by reducing engineering time. We believe that the several years until 2007 allow enough lead time for manufacturers to carry out this development effort for all their engines.

We expect the SwRI testing program to provide extensive, basic information on optimizing the subject engines for low emissions, so manufacturers will need significantly less time and testing resources to modify additional engine models. For example, the SwRI testing shows how emissions change over varying speeds and loads; as a result, future testing can focus on far fewer test points to characterize a calibration. The test results also show how manufacturers will need to balance calibrations for controlling emissions of different pollutants across the range of engine speeds and loads.

The emission standards for Large SI engines are significantly more stringent than those we are adopting for recreational vehicles and those we have already adopted for lawn and garden engines. We believe this is appropriate, for several reasons. First, the similarity to automotive engines makes it possible to use basic automotive technology that has already been adapted to industrial use. Second the cost of Large SI equipment is typically much higher than the recreational or other light-duty products, so there is more capability for manufacturers to pass along cost increases in the marketplace. Third, the Large SI emission standards correspond with a substantial fuel savings, which offset the cost of regulation and provide a great value to the many commercial customers.

4.2.3 Impacts on Noise, Energy, and Safety

The Clean Air Act directs us to consider potential impacts on noise, energy, and safety when establishing the feasibility of emission standards for nonroad engines.

As automotive technology demonstrates, achieving low emissions from spark-ignition engines can correspond with greatly reduced noise levels. Electronically controlled fuel systems are able to improve management the combustion event, and catalysts can be incorporated into existing equipment designs without compromising the muffling capabilities in the exhaust.

Adopting new technologies for controlling fuel metering and air-fuel mixing will lead to substantial improvements in fuel consumption rates. We project fuel consumption improvements that will reduce total nationwide fuel consumption by about 300 million gallons annually once the program is fully phased in. While a small number of engines already have these technologies, it seems that the industrial engine marketplace has generally not valued fuel economy highly enough to create sufficient demand for these technologies.

We believe the technology discussed here will have no negative impacts on safety. Electronic fuel injection is almost universally used in cars and trucks in the United States with very reliable performance. In addition, we expect cases of CO poisoning from these engines to decrease as a result of the reduced emission levels.

4.3 Snowmobile Engines

The following paragraphs summarize the data and rationale supporting the emission standards for snowmobiles, which are listed in the Executive Summary.

4.3.1 Baseline Technology and Emissions

Snowmobiles are equipped with relatively small high-performance two-stroke two and three cylinder engines that are either air- or liquid-cooled. The main emphasis of engine design is on performance, durability, and cost. Because these engines are currently unregulated, they have no emission controls. The fuel system used on these engines are almost exclusively carburetors, although a small number have electronic fuel injection. Two-stroke engines lubricate the piston and crankshaft by mixing oil with the air and fuel mixture. This is accomplished by most contemporary 2-stroke engines with a pump that sends two-cycle oil from a separate oil reserve to the carburetor where it is mixed with the air and fuel mixture. Some less expensive two-stroke engines require that the oil be mixed with the gasoline in the fuel tank. In fact, because performance and durability are such important qualities for snowmobile engines, they all operate with a "rich" air and fuel mixture. That is, they operate with excess fuel, which enhances performance and allows engine cooling which promotes longer lasting engine life. However, rich operation results in high levels of HC, CO, and PM emissions. Also, two-stroke engines tend to have high scavenging losses, where up to a third of the unburned air and fuel mixture goes out of the exhaust resulting in high levels of raw HC.

We developed average baseline emission rates for snowmobiles based on the results of emissions testing of 23 snowmobiles.[23] Current average snowmobile emissions rates are 397 g/kW-hr (296 g/hp-hr) CO and 149 g/kW-hr (111 g/hp-hr) HC.

4.3.2 Potentially Available Snowmobile Technologies

A variety of technologies are currently available or in stages of development to be available for use on 2-stroke snowmobiles. These include engine modifications, improvements to carburetion (improved fuel control and atomization, as well as improved production tolerances), enleanment strategies for both carbureted and fuel injected engines, pulse air, and semi-direct and direct fuel injection. In addition to these 2-stroke technologies, it is also feasible to convert from using 2-stroke engines to 4-stroke engines. Each of these is discussed in the following sections.

4.3.2.1 Engine Modifications

There are a variety of engine modifications that could reduce emissions from two-stroke engines. The modifications generally either increase trapping efficiency (i.e., reduce fuel short-circuiting) or improve combustion efficiency. Those modifications that increase trapping efficiency include optimizing the intake, scavenge and exhaust port shape and size, and port placement, as well as optimizing port exhaust tuning and bore/stroke ratios. Optimized combustion charge swirl, squish, and tumble improve the combustion of the intake charge. Various snowmobile manufacturers have told us that they believe these modifications have the potential to reduce emissions by up to 40 percent, depending on how well the unmodified engine is optimized for these changes[v].

4.3.2.2 Carburetion Improvements

There are several things that can be done to improve carburetion in snowmobile engines. First, strategies to improve fuel atomization promote more complete combustion of the fuel/air mixture. Additionally, production tolerances can be improved for more consistent fuel metering. Both of these allow for more accurate control of the air/fuel ratio. In conjunction with these improvements in carburetion, the air/fuel ratio can be leaned out somewhat. Snowmobile engines are currently calibrated with rich air/fuel ratios for durability reasons. Manufacturers have stated that based on their experience, leaner calibrations can reduce CO and HC emissions by up to 20 percent, depending on how lean the unmodified engine is prior to recalibration[w]. Small improvements in fuel economy can also be expected with recalibration.

The calibration changes just discussed (as well as some of the engine modifications previously discussed) also reduce snowmobile engine durability, though many possible engine improvements could regain any lost durability that occurs with leaner calibrations. These include changes to the cylinder head, pistons, ports and pipes to reduce knock. In addition, critical engine components can be made more robust to improve durability.

The same calibration changes to the air/fuel ratio just discussed for carbureted engines can also be employed, possibly with more accuracy, with fuel injection. At least one major snowmobile manufacturer currently employs electronic fuel injection on several of its snowmobile models.

4.3.2.3 Pulse Air

Pulse air injection into the exhaust stream mixes oxygen with the high temperature HC and CO in the exhaust. The added oxygen allows the further combustion of these exhaust constituents between the combustion chamber and tailpipe exhaust. Our testing of pulse air on four-stroke ATV engines indicated that reductions of 30-70% for HC and 30-80% for CO are possible. We believe similar reductions could be expected for engines used in snowmobile applications. We expect some modest reductions in two-stroke applications as well.

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[v] See “Memo to Docket on Technical Discussions with Recreational Vehicle Manufacturers,” from Linc Wehrly. Docket A-2000-01, IV-B-43.

[w] See “Memo to Docket on Technical Discussions with Recreational Vehicle Manufacturers,” from Linc Wehrly. Docket A-2000-01, IV-B-43.

4.3.2.4 Direct and Semi-direct Fuel Injection

In addition to rich air/fuel ratios, one of the main reasons that emissions from two-stroke engines are high is scavenging losses, as described above. One way to reduce or eliminate such losses is to inject the fuel into the cylinder after the exhaust port has closed. This can be done by injecting the fuel into the cylinder through the transfer port (semi-direct injection) or directly into the cylinder (direct injection). Both of these approaches are currently being used successfully in two-stroke personal watercraft (PWC) engines. Bombardier has developed a semi-direct injection engine for snowmobiles that will be available in several different models for the 2003 model year. Manufacturers have indicated to us that two-stroke engines equipped with direct fuel injection systems could reduce HC emissions by 70 to 75 percent and reduce CO emissions by 50 to 70 percent. Certification results for 2002 model year PWC support the manufacturers projections, as shown in Table 4.3-1. This table shows the paired certification data from some PWC engines in both uncontrolled and direct injection configurations. The percent difference in FEL column refers to the HC + NOx FEL. This is a pretty good surrogate for HC since most of the HC + NOx level is made up of HC, as can be seen from the table.

Table 4.3-1
Certification Levels of Direct Injection vs. Uncontrolled Engines

Mfr	% difference in FEL	size (liter)	power (kW)	FEL (HC + NOx)	HC cert level	CO cert level	Technology
Kawasaki	67%	1.071	95.6	46.0	38.4	103.1	Direct injection, electronic control
		1.071	88.3	140.0	136.76	241.8	Carburetor
Polaris	72%	0.78	Not Reported	47.1	33.2	135.2	Direct injection
		0.70	Not Reported	165	158.8	217.0	Carburetor
Bombardier	73%	0.9514	88.9	36.8	24.5	100.1	Direct injection, electronic control
		0.9513	89.5	137.8	136.7	330.6	Carburetor
Polaris	65%	1.16	85.26	46.3	37.46	100.4	Direct injection
		1.16	93.25	134.0	130.8	359.3	Carburetor

Substantial improvements in fuel economy could also be expected with these technologies. We believe these technologies hold promise for application to snowmobiles. All four of the major snowmobile manufacturers have indicated that they consider direct fuel injection as a viable technology for controlling emissions and are currently either analyzing various direct injection systems or are in the process of developing their own system.

Manufacturers must address a variety of technical design issues for adapting the technology to snowmobile operation, such as operating in colder ambient temperatures and at variable altitude. Manufacturers have also stated that the direct injection systems used in many of their PWC cannot simply be placed into their snowmobiles because of inherent differences in snowmobile and PWC engines. Primarily the fact that PWC engines operate at considerably lower engine speeds than snowmobile engines. PWC engines typically operate at maximum engine speeds of 6,000 rpm, compared to engine speeds of almost double that for snowmobiles. This poses a problem because some of the current direct injection designs can't properly operate at such high engine speeds. While these are all legitimate concerns, we believe that this technology can be adapted without significant problems. Bombardier's use of direct fuel injection in several snowmobile models in the 2003 model year demonstrates that these issues have been resolved enough for Bombardier to be comfortable selling snowmobiles with such engines. However, direct fuel injection is a complex technology and there are several different types of approaches to designing these systems and not all manufacturers have the same access to the various systems. Therefore, it appears important to provide manufacturers with sufficient lead time to resolve all of the potential issues with direct injection so that it can be widely available for all snowmobile models, instead of a few niches models for a select manufacturer or two. That is why we believe it is appropriate to give manufacturers until 2012. This will give manufacturers sufficient time to incorporate these development efforts into their overall research plan and apply these technologies to a substantial percentage of their snowmobiles.

4.3.2.5 Four-Stroke Engines

In addition to the two-stroke technologies just discussed, the use of four-stroke engines in snowmobiles is feasible. Four-stroke engines have been used in numerous recreational vehicle applications for years. Four-stroke engines have also been used in limited numbers over the years in snowmobiles. In 1999, Arctic Cat released a four-stroke touring sled. Polaris followed two years later with their four-stroke touring sled in 2001. Table 4.3-2 provides emission results from a 2001 Arctic Cat four-stroke touring sled and a 2001 Polaris Frontier (four-stroke), both owned and tested by the National Park Service (NPS) at Southwest Research Institute. Table 4.3-3 presents certification data from four 2002 PWC's equipped with four-stroke engines. The engines in these PWC are higher output engines than the Arctic Cat and Polaris snowmobile four-stroke engines and have emission results very similar to that which a high-output four-stroke snowmobile engine could expect to emit.

Table 4.3-2
Four-Stroke Snowmobile Emissions

Manufacturer	Model	Engine Displacement	HC (g/kW-hr)	CO (g/kW-hr)	NOx (g/kW-hr)
Arctic Cat	4-Stroke Touring	660 cc	6.2	79.9	15.0
Polaris	Frontier	784 cc	3.2	79.1	7.0

Table 4.3-3
Four-Stroke PWC Certification Emission results

Manufacturer	Model	Engine Displacement	HC (g/kW-hr)	CO (g/kW-hr)	NOx (g/kW-hr)
Honda	Aqua Trax F-12	1,244 cc	11.2	266.0	3.8
Honda	Aqua Trax F-12X	1,244 cc	10.7	235.3	4.6
Bombardier	GTX 4-TEC	1,504 cc	9.6	161.7	5.0
Yamaha	FX140	998 cc	16.6	255.1	5.9

Much has changed in the time since we published our proposed standards. In October 2001, when we published our proposed standards for snowmobiles, there was only one manufacturer that had introduced a four-stroke snowmobile (the Polaris Frontier was released soon after). Today, all four of the major snowmobile manufacturers have developed a four-stroke engine for snowmobiles. In fact, the 2003 model year will see four-stroke engines in several models from all four manufacturers. The models will range from touring sleds to sport, mountain, and high-performance models. Since four-stroke engines do not rely on scavenging of the exhaust gases with the incoming air/fuel mixture, they have inherently lower HC emissions compared to two-strokes (up to 90 percent lower). Four-stroke engines can also have reductions in CO emissions, depending on the power output of the engines and the engine calibration. A smaller four-stroke engine calibrated to operate at or near stoichiometry could reduce CO emissions significantly. This is demonstrated above in Table 4.3-2, since both of these snowmobiles use four-stroke engines equipped with closed-loop control EFI systems which try to maintain the air and fuel mixture at or near stoichiometry. A larger four-stroke engine calibrated for maximum power could generate CO emission levels closer to a comparably powered two-stroke engine. Table 4.3-3 above, demonstrates this. Although the engines in this table are from PWCs, they are high-output four-stroke engines producing horsepower in excess of 100 hp, that are very similar to what could be expected to be used in a high-performance snowmobile. The CO emissions from the four PWC engines are considerably higher than the CO levels from the two lower powered four-stroke snowmobiles. Four-stroke engines have a lower power density compared to two-stroke engines. Two-stroke engines have a power stroke every other stroke compared to a power stroke every fourth stroke for a four-stroke engine. Thus, a comparably powered four-stroke engine requires almost a third more engine displacement, to equal the power of a two-stroke engine. The impact this has on snowmobile applications is that a four-stroke engine is already heavier than a two-stroke engine because of the valve-train system. In order to have comparable power output with a two-stroke, a four-stroke engine needs to have a larger displacement. This is achieved through an increase in the cylinder bore and/or stroke or by adding more cylinders, which all have the potential effect of adding even more weight. Thus, for a four-stroke to be competitive with a two-stroke engine, manufacturers need to find a way to reduce weight in the engine and elsewhere in the snowmobile. This could entail the use of lighter materials in the engine and chassis or reducing the size of the fuel tank to take advantage of the superior fuel efficiency of the four-stroke engine while maintaining the same cruising time/range.

Another way to increase the output from a four-stroke engine is to use a turbocharger or supercharger. Both of these devices act as air compressors, providing increased air density in the engines's combustion chambers, which allows more efficient burning of air and fuel and results in higher horsepower output. A turbocharger uses exhaust gases to compress air, while a supercharger is mechanically driven using a belt between the supercharger and typically the camshaft. Honda is currently selling a turbocharged version of their four-stroke personal watercraft. A turbocharger or supercharger could provide an increase in power without having to increase the engine displacement. Regardless of the strategy used, it is apparent that four-stroke engines will have a larger role in snowmobile applications than originally thought.

However, it is important to provide sufficient lead time for the development and implementation of some four-stroke engines in snowmobiles, similar to the concern with direct fuel injection. For example, in the case of the Yamaha four-stroke snowmobile, a considerable amount of effort and resources went into designing a new snowmobile from the ground up specifically to accommodate the size, weight and power characteristics of a four-stroke engine. A completely new chassis was designed which allowed the somewhat heavier engine to be placed lower and further back than is typical for two-stroke snowmobiles. This was necessary to maintain the kind of handling characteristics required of a high performance snowmobile. While a stock four-stroke engine can be placed into an existing snowmobile model and made to work acceptably, as can be seen in the Polaris and Arctic Cat four-stroke offerings, such designs are only practical for lower powered touring snowmobiles. Since the vast majority of the snowmobile market is in higher performance sleds, we believe that the conversion of all snowmobiles to four-strokes would require that many current snowmobile chassis be replaced with new models designed from the ground up. This could be a substantial undertaking for the snowmobile industry given the number of models it offers and niche markets it currently serves. That is why we believe the delay of our proposed Phase 2 standards by two years will give manufacturers time to incorporate these development efforts into their overall research plan as they apply these technologies to their snowmobiles.

4.3.3 Test and Measurement Issues

4.3.3.1 Test procedure

We are generally adopting the snowmobile test procedure developed by Southwest Research Institute in cooperation with the International Snowmobile Manufacturers Association for all snowmobile emissions testing.[24] This test procedure consists of two main parts; the duty cycle that the snowmobile engine operates over during testing and other testing protocols involving the measurement of emissions (sampling and analytical equipment, specification of test fuel, atmospheric conditions for testing, etc.). While the snowmobile duty cycle was developed specifically to reflect snowmobile operation, many of the testing protocols are well established in other EPA emissions programs and have been simply adapted where appropriate for snowmobiles.

The snowmobile duty cycle was developed by instrumenting several snowmobiles and operating them in the field in a variety of typical riding styles, including aggressive (trail), moderate (trail), double (trail with operator and one passenger), freestyle (off-trail), and lake driving. A statistical analysis of the collected data produced the five mode steady-state test cycle shown in Table 4.3-4. The snowmobiles used to generate this data were not derived from members of the general public found openly operating in these riding styles, but were snowmobiles operated by contractor personnel in staged set-ups of these riding styles. This duty cycle was used to generate the baseline emissions levels for snowmobiles, and we believe it is the most appropriate cycle for demonstrating reductions in snowmobile emissions at this time.

Table 4.3-4
Snowmobile Engine Test Cycle

Mode	1	2	3	4	5
Normalized Speed	1	0.85	0.75	0.65	Idle
Normalized Torque	1	0.51	0.33	0.19	0
Relative Weighting (%)	12	27	25	31	5

The other testing protocols are largely derived from our regulations for marine outboard and personal watercraft engines.[25] The testing equipment and procedures from that regulation are largely appropriate for snowmobiles. However, unlike snowmobiles, outboard and personal watercraft engines tend to operate in fairly warm ambient temperatures. Thus, some provision needs to be made in the snowmobile test procedure to account for the colder ambient temperatures typical of snowmobile operation. Since snowmobile carburetors are jetted for specific ambient temperatures and pressures, we could take one of two general approaches. The first is to require testing at ambient temperatures typical of snowmobile operation, with appropriate jetting. A variation of this option is to simply require that the engine inlet air temperature be representative of typical snowmobile operation, without requiring that the entire test cell be at that temperature. The second is to allow testing at higher temperatures than typically experienced during snowmobile operation, with jetting appropriate to the warmer ambient temperatures.

Manufacturers shared confidential emission data with us that indicated that there was no difference between testing snowmobiles with cold inlet air and testing at higher temperatures with carburetor jetting adjusted for the warmer temperature. We also did some limited testing which substantiates the manufacturer's claim. Some manufacturers argued that even though there was no difference between the test methods, we should still require testing with cold inlet air because it would be more representative. Other manufacturers felt that the increased cost of cold inlet air testing made this approach undesirable. We decided that since there was ample evidence that two approaches would produce similar results with the technologies we expect to be used and that it did not make sense to require manufacturers to incur the cost of cold inlet air testing if it wouldn't provide any additional benefit. Therefore, we are allowing manufacturers to test at warmer (i.e., typical test cell temperature 68°F-86°F) with carburetor jetting set to the appropriate temperature.

4.3.3.2 HC is a Good Proxy for Fine PM Emissions

We believe the best way to regulate fine PM emissions from current snowmobile engines is to set standards based on HC emissions. Unlike other recreational vehicles, the current fleet of snowmobiles consists almost exclusively of two-stroke engines. Two-stroke engines inject lubricating oil into the air intake system where it is combusted with the air and fuel mixture in the combustion chamber. This is done to provide lubrication to the piston and crankshaft, since the crankcase is used as part of the fuel delivery system and cannot be used as a sump for oil storage as in four-stroke engines. As a result, in addition to products of incomplete combustion, two-stroke engines also emit a mixture of uncombusted fuel and lubricant oil. HC-related emissions from snowmobiles increase PM concentrations in two ways. Snowmobile engines emit HCs directly as particles (e.g., droplets of lubricant oil). Snowmobile engines also emit HC gases, as well as raw unburned HCs from the fuel which either condense in cold temperatures to particles or react chemically to transform into particles as they move in the atmosphere. As discussed above, fine particles can cause a variety of adverse health and welfare effects, including visibility impairment.

We believe HC measurements will serve as a reasonable surrogate for fine PM measurement for snowmobiles for several reasons. First, emissions of PM and HC from these engines are related. Test data show that over 70 percent of the average volatile organic fraction of PM from a typical 2-stroke snowmobile engine is organic hydrocarbons, largely from lubricating oil components.[x] The HC measurements (which use a 191 Celsius/375.8 degree

[x]Memo to Docket, Mike Samulski. "Hydrocarbon Measurements as an Indicator for Particulate Matter Emissions in Snowmobiles," September 6, 2002, Docket A-2000-01; Document IV-B.

Carroll, JN, JJ White, IA Khalek, NY Kado. Characterization of Snowmobile Particulate Emissions. Society of Automotive Engineers Technical Paper Series. Particle Size Distribution in the Exhaust of Diesel and Gasoline. SP-1552, 2000-01-2003. June 19-22, 2000.

Fahrenheit heated FID) would capture the volatile component which in ambient temperatures would be particles (as droplets).

Second, many of the technologies that will be employed to reduce HC emissions are expected to reduce PM (e.g., 4-stroke engines, pulse air, and direct fuel injection techniques). The organic emissions are a mixture of fuel and oil, and reductions in the organic emissions will likely yield both HC and PM reductions. For example, the HC emission factor for a typical 2-stroke snowmobile is 111 g/hp-hr. The HC emission factor for a direct fuel injection engine is 21.8, and for a 4-stroke is 7.8 g/hp-hr, representing a 80 percent and 99 percent reduction, respectively. Similarly, the PM emission factor for a typical 2-stroke snowmobile is 2.7 g/hp-hr. The corresponding PM emission factor for a direct fuel injection engine is 0.57, and for a 4-stroke is 0.15 g/hp-hr, representing a 75 percent and 93 percent reduction, respectively. HC measurements would capture the reduction from both the gas and particle (at ambient temperature) phases.

Thus, manufacturers will generally reduce PM emissions as a result of reducing HC emissions, making separate PM standards less necessary. Moreover, PM standards would only cover the PM directly emitted at the tailpipe. It would not measure the gaseous or semi-volatile organic emissions which would condense or be converted into PM in the atmosphere. By contrast HC measurements would include the gaseous HC which could condense or be converted into PM in the atmosphere. Thus, the HC measurement would be a more comprehensive measurement. HC standards actually will reduce secondary PM emissions that would not necessarily be reduced by PM standards.

Finally, from an implementation point of view, PM is not routinely measured in snowmobiles, and there is no currently established protocol for measuring PM and substantial technical issues to overcome to create a new method. Establishing additional PM test procedures would entail additional costs for manufacturers. HC measurements are more routinely performed on these types of engines, and these measurements serve as a more reliable basis for setting a numeric standard. Thus, we believe that regulation of HC is the best way to reduce PM emissions from current snowmobile engines.

We included a NOx standard for snowmobiles as part of the long-term program. NOx emissions from current snowmobiles are very small, especially compared to HC. This standard will essentially cap NOx emissions from these engines to prevent backsliding in advanced technology engines. We are not promulgating standards that would require substantial reductions in NOx because we believe that non-aftertreatment based standards which force substantial NOx reductions could put upward pressure on HC emissions and would not necessarily lead to reductions in ambient PM. Given the overwhelming level of HC, CO and PM compared to NOx, and the secondary PM expected to result from high HC levels, it would be premature and possibly counterproductive to promulgate NOx standards that require significant NOx reductions from snowmobiles at this time. We have therefore decided to structure our long term HC+NOx standard for 2012 and later model year snowmobiles to require only a cap on NOx emissions from the advanced technology engines which will be the dominant technology in the new snowmobiles certified at that time.

4.3.4 Impacts on Noise, Energy, and Safety

The Clean Air Act directs us to consider potential impacts on noise, energy, and safety when establishing the feasibility of emission standards for nonroad engines.

As automotive technology demonstrates, achieving low emissions from spark-ignition engines can correspond with greatly reduced noise levels. Four-stroke engines can have considerably lower sound levels than two-stroke engines. Electronically controlled fuel systems are able to improve management of the combustion event which can help lower noise levels.

Adopting new technologies for controlling fuel metering and air-fuel mixing will lead to substantial improvements in fuel consumption rates for two-stroke engines as well as for four-stroke engines. Four-stroke engines have far less fuel consumption than two-stroke engines. Average mileage for a baseline two-stroke snowmobile is 12 miles per gallon (mpg). Average mileage for a four-stroke snowmobile is 18 mpg and up to 20 mpg for a two-stroke with direct injection. We project that these fuel consumption benefits will reduce total nationwide fuel consumption by more than 50 million gallons annually once the program is fully phased in.

We believe the technology discussed here will have no negative impacts on safety. Electronic fuel injection is almost universally used in cars, trucks and highway motorcycles in the United States with very reliable performance. While the manufacturers have expressed some concern about heavier weight and cold-starting for four stroke engines we believe these are not significant concerns. There are already four-stroke models in production today and obviously they are not being introduced into commerce with known safety concerns. A two-stroke snowmobile has a fuel tank of about 12 gallons. A four-stroke could have a fuel tank of 8 gallons and maintain the same driving time/range. This would lead to a weight reaction of 25 pounds to help offset concerns about increased weight of four-stroke snowmobiles. If cold starting of four strokes is an issue, it can be resolved with the assistance of an electronic starter or a dry sump oil system that stores oil in a separate tank rather than in the crankcase, thus eliminating the concern over high viscous oil adding excessive resistance to the starting process.

4.3.5 Conclusions

4.3.5.1 Phase 1 Standards

For the Phase 1 standards which start in the 2006 model year, we are allowing a phase-in schedule that requires 50 percent of a manufacturers snowmobile fleet to meet the standards in the 2006 model year and 100 percent to meet the standards in the 2007 model year. Snowmobile manufacturers will have three main emission control technologies for meeting these standards: modified two-stroke technologies (combination of engine modifications and fuel system improvements), direct fuel injection, and four-stroke engine technology. We expect that the Phase 1 emission standards will be met through a combination or mixture of these three emission control strategies. All three of these strategies have been proven to be feasible and are already available on some sleds today. Four-stroke engines and direct fuel injection technology have already been demonstrated to be capable of achieving emission reductions well in excess of our standards. Significant reductions are also achievable using modified two-stroke technologies.

For the 2006 model year, we expect manufacturers to rely most heavily on modifications to existing two-stroke engines with a small amount (e.g., 10 percent) of direct injection two-stroke engines and four-stroke engines (e.g., another 10 percent). In the context of an averaging program, the use of direct injection technology and four-stroke engines will not only be necessary to meet the standards, but may also allow some manufacturers to leave a small percentage of engines unchanged, most specifically, inexpensive entry-level sleds that manufacturers have argued are very cost sensitive. Such an approach may be necessary given the lead time and the fairly large number of engine models to be modified and certified. Table 4.3-5 provided below presents a potential technology mix scenario for the Phase 1 standards. The average reduction level at the bottom of the table represents average reductions for a manufacturer's entire fleet which already incorporates compliance margin and useful life consideration, since each engine family FEL will have a unique compliance margin. The percent reduction presented in the table is based on HC and CO. Obviously, a manufacturer could change the technology mix based on cost and performance considerations.

Table 4.3-5
Potential Snowmobile Technology Mix for Phase 1 Standards

Technology	Percent Usage	Percent Reduction HC	Percent Reduction CO	Fleet % Reduction HC	Fleet % Reduction CO
Minimal Control Engines*	20%	0%	0%	0%	0%
Carburetor/EFI Recalibration + Engine Modifications	60%	30%	30%	18%	18%
Direct Injection	10%	75%	70%	7.5%	7%
Four-Stroke	10%	90%	50%	9%	5%
Average Reduction				35%	30%

* Some minimal control may be required to account for deterioration and to ensure certification FELs are met in production.

4.3.5.2 Phase 2 Standards

We are also finalizing Phase 2 standards in the 2010 model year that will serve as transitional standards to our more stringent Phase 3 standards. As for the Phase 1 standards, we believe manufactures will rely on a mixture of technologies, with the focus on modified two-stroke technologies, perhaps including pulse air injection, direct fuel injection, and four-stroke engines. We expect that to meet the 2010 standards, manufacturers will employ more of the advanced technologies such as direct injection and four-stroke engines and less of the modified two-stroke technologies. We anticipate manufacturers will have numerous technology mix scenarios that they will consider.   Table 4.3-6 provided below presents a potential technology mix scenario for the Phase 2 standards. Obviously, a manufacturer could change the technology mix based on cost and performance considerations. As for the Phase 1 standards, the use of advanced technologies such as direct injection and four-stroke engines, in the context of our averaging program, may allow some manufacturers to have a small percentage of engines with minimal change. As discussed above in sections 4.3.2.4 and 4.3.2.5, we believe the biggest task manufacturers will face in meeting our standards will be the converting of their large current fleet of snowmobiles equipped with unregulated two-stroke engines to snowmobiles equipped with advanced clean technologies, such as direct injection and four-stroke engines.

Table 4.3-6
Potential Snowmobile Technology Mix for 2010 Standards

Technology	Percent Usage	Percent Reduction HC	Percent Reduction CO	Fleet % Reduction HC	Fleet % Reduction CO
Minimal Control Engines*	20%	0%	0%	0%	0%
Carburetor/EFI Recalibration + Engine Modifications + Pulse Air Injection	30%	35%	35%	10.5%	10.5%
Direct Injection	35%	75%	70%	26%	24.5%
Four-Stroke	15%	90%	50%	13.5%	7.5%
Average Reduction				50%	43%

* Some minimal control may be required to account for deterioration and to ensure certification FELs are met in production.

4.3.5.3 Phase 3 Standards

We are finalizing Phase 3 standards in the 2012 model year that we believe will require a significant percentage of snowmobile models to be equipped with advanced technologies. As with our Phase 1 and Phase 2 standards, we believe manufactures will rely on a mixture of technologies, with the focus on direct fuel injection and four-stroke engines. While we expect that to meet the 2012 standards manufacturers will employ considerably more of the advanced technologies such as direct injection and four-stroke engines, they may still use a relatively small amount of the modified two-stroke technologies. To provide manufacturers with additional flexibility, we are allowing the Phase 3 standards to be met by using the following equation:

$$100 = \left(1 - \frac{(HC + NOx)_{STD} - 15}{150}\right) \times 100 + \left(1 - \frac{CO_{STD}}{400}\right) \times 100$$

Under this equation, the sum of reductions in HC+NOx and CO must equal or exceed 100 percent on a corporate average basis. Corporate average HC levels cannot exceed 75 g/kW-hr as in the Phase 2 requirement. We believe this will allow manufacturers to use a broader variety of technology mixes than our proposed Phase 2 standards. Tables 4.3-7 and 4.3-8 provided below present a couple of potential technology mix scenarios for the Phase 3 standards. For the Phase 3 standards, we are including a HC+NOx requirement. This was done because, as the tables below will show, the number of four-stroke snowmobiles is anticipated to significantly increase compared to the number used to meet our Phase 1 and Phase 2 standards. Four-stroke engines emit significantly higher levels of NOx emissions than two-stroke engines. In order to make sure that NOx emissions do not become a problem as a result of the increase in the number of four-stroke snowmobiles, we decided to establish a NOx standard as well. The NOx standard is set at a level that makes it more of a cap, 15 g/kW-hr. This level should be inherently achievable for the majority of four-stroke engines. However, should a manufacturer attempt to design a four-stroke snowmobile that operates with a very lean air and fuel mixture to get even further HC reductions, this standard will prevent backsliding. NOx emissions from two-stroke engines are inherently well below the 15 g/kW-hr level.

We do not believe that incorporating the 15 g/kW-hr NOx standard as part of the HC+NOx standard will provide any incentive to increase HC significantly. NOx emissions from four-stroke engines are sufficiently close to 15 g/kW-hr that there will be little ability to increase HC even marginally. For two-stroke engines, while the 15 g/kW-hr level for NOx is well above typical two-stroke NOx emissions, it is still well below two-stroke HC emissions and does not provide enough of a margin to avoid use of advanced technologies on most engines. At most, it may provide a slight compliance cushion for these engines.

Table 4.3-7
Potential Snowmobile Technology Mix for Phase 3 Standards

Technology	Percent Usage	Percent Reduction HC	Percent Reduction CO	Fleet % Reduction HC	Fleet % Reduction CO
Carburetor/EFI Recalibration + Engine Modifications + Pulse Air Injection	20-30%	23-35%	23-35%	7-11.5%	7-11.5%
Direct Injection	50%	75%	70%	37.5%	35%
Four-Stroke	20%	90%	50%	18%	10%
Average Reduction				63%	52%

Table 4.3-8
Potential Snowmobile Technology Mix for Phase 3 Standards

Technology	Percent Usage	Percent Reduction HC	Percent Reduction CO	Fleet % Reduction HC	Fleet % Reduction CO
Carburetor/EFI Recalibration + Engine Modifications + Pulse Air Injection	0-20%	0-35%	0-35%	0-7%	0-7%
Direct Injection	10%	75%	70%	7.5%	7%
Four-Stroke	70%	90%	50%	63%	35%
Average Reduction				71%	42%

Clearly the technologies necessary to meet our 2012 standards are feasible, and in many cases the technologies are already being used on various snowmobile applications. As these technologies have been shown to provide emission reductions at or beyond the reductions needed to meet the standards, the standards are clearly feasible given the appropriate lead time even when considering production variability and emissions deterioration. The challenge manufacturers will face will be deciding which technologies to use for different applications and how consumers will respond to those technologies. In our testing efforts we attempted to order one of the new 2003 Yamaha RX-1 high performance four-stroke snowmobiles, but were surprised to find out that local dealers said there would be a six month wait to get one due to the high demand. We verified with Yamaha that they indeed have commitments for virtually every one of the new RX-1 models they are making and it's not a limited run, but rather a full scale production build. Therefore, if the Yamaha case is any indication, we believe there are a number of viable technologies available to meet our 2010 standards and the public is not only going to accept them, but embrace them.

Tables 4.3-7 and 4.3-8 are meant to show some possible technology mix scenarios that manufacturers may choose to comply with the Phase 3 standards in 2012. Implicit in these tables is the possibility that, under the averaging program, there may still be some largely unmodified two-stroke engines sold under the Phase 3 program. There are several reasons why a manufacturer might choose to continue to sell a small number of baseline technology snowmobiles under the Phase 3 program. First, it may prove significantly more expensive to reduce the emissions of a particular engine family relative to a manufacturer's other product offerings, and the manufacturer may simply choose to apply additional technology to some of its other models rather than put the extra effort and expense into reducing emissions from every one of its models. Second, a particular engine family may not respond as well to technology changes as other engine families, and the manufacturer may choose to apply additional technology to some of its other offerings rather than spending the resources to overcome the technological hurdles associated with a particular engine family. This could be because the technologies may affect the performance of the particular snowmobile model, including increased weight and startability concerns, and thus need further refinement for implementation. Finally, a manufacturer may intend to discontinue a particular engine family in the near future and may choose to focus its efforts on its other product offerings rather than spend the resources to reduce emissions from an engine family that is scheduled to be discontinued.

While it is possible that there may be some baseline technology snowmobiles in the product mix under the Phase 3 program, we expect that sales of such snowmobiles will be minimal for the following reasons. First, as Tables 4.3-7 and 4.3-8 show, we expect that compliance with the Phase 3 standards will require that at least 70 percent of snowmobile production employ some form of advanced technology such as direct injection two-stroke technology, or four-stroke engines. There may be some uncertainty amongst manufacturers as to whether they will be able to sell enough snowmobiles with advanced technology to allow for including baseline technology snowmobiles in their product mix. Manufacturers will likely choose to apply some level of emissions control to every snowmobile they sell in order to assure compliance with the Phase 3 standards on average. Similarly, there is no assurance that the advanced technologies will reduce emissions as well as expected on all engine families in the time frame provided, and we expect that manufacturers will also choose to apply some level of technology to every snowmobile in order to provide a compliance margin in case some technologies or particular applications of technologies do not perform as expected.

4.4 All-Terrain Vehicles/Engines

The following paragraphs summarize the data and rationale supporting the emission standards for ATVs, which are listed in the Executive Summary.

4.4.1 Baseline Technology and Emissions

ATVs have been in popular use for over 25 years. Some of the earliest and most popular ATVs were three-wheeled off-highway motorcycles with large balloon tires. Due to safety concerns, the three-wheeled ATVs were phased-out in the mid-1980s and replaced by the current and more popular vehicle known as "quad runners" or simply "quads." Quads resemble the earlier three-wheeled ATVs except the single front wheel was replaced with two wheels that are controlled by a steering system. The ATV steering system uses motorcycle handlebars, but otherwise looks and operates like an automotive design. The operator sits on and rides the quad much like a motorcycle. The engines used in quads tend to be very similar to those used in off-highway motorcycles - relatively small single cylinder two- or four-stroke engines that are either air- or liquid-cooled. Recently, some manufacturers have introduced ATVs equipped with larger four-stroke two-cylinder V-twin engines. Quads are typically divided into two types: utility and sport. The utility quads are designed for recreational use but have the ability to perform many utility functions such as plowing snow, tilling gardens, and mowing lawns to name a few. They are typically heavier and equipped with relatively large four-stroke engines and automatic transmissions with reverse gear. Sport quads are smaller and designed primarily for recreational purposes. They are equipped with two- or four-stroke engines and manual transmissions.

Although ATVs are not currently regulated federally, they are regulated in California. The California ATV standards are based on the FTP cycle just like highway motorcycles, however, California allows manufacturers to optionally certify to a steady-state engine cycle (SAE J1088) and meet the California non-handheld small SI utility engine standards. Manufacturers have felt that these standards are unattainable with two-stroke engine technology. Therefore, all of the ATVs certified in California are equipped with four-stroke engines. California ultimately allowed manufacturers to sell uncertified engines as long as those ATVs and motorcycles equipped with uncertified engines were operated exclusively on restricted public lands and at specified times of the year. This allowed manufacturers to continue to produce and sell two-stroke ATVs in California. Thus, the main emphasis of ATV engine design federally, and for two-stroke powered ATVs in California, is on performance, durability, and cost. Although some manufacturers offer some of their California models nationwide, most ATVs sold federally have no emission controls.

ATVs predominantly use four-stroke engines (e.g., 80 percent of all sales are four-stroke). The smaller percentage of two-stroke engines are found primarily in the small engine displacement "youth" models. Of the seven major ATV manufacturers, only two make two-stroke ATVs for adults. These models are either inexpensive entry models or high-performance sport models. The fuel system used on ATVs, whether two- or four-stroke, are almost exclusively carburetors, although at least one manufacturer has introduced a four-stroke ATV with electronic fuel injection. Although ATVs are mostly four-stroke equipped, they still can have relatively high levels of HC and extremely high levels of CO, because many of them operate with a "rich" air and fuel mixture, which enhances performance and allows engine cooling, which promotes longer lasting engine life. This is also true for two-stroke equipped ATVs. Rich operation results in high levels of HC, CO, and PM emissions. In addition, two-stroke engines lubricate the piston and crankshaft by mixing oil with the air and fuel mixture. This is accomplished by most contemporary 2-stroke engines with a pump that sends two-cycle oil from a separate oil reservoir to the carburetor where it is mixed with the air and fuel mixture. Some less expensive two-stroke engines require that the oil be mixed with the gasoline in the fuel tank. Because two-stroke engines tend to have high scavenging losses, where up to a third of the unburned air and fuel mixture goes out of the exhaust, lubricating oil particles are also released into the atmosphere, becoming HC particles or particulate matter (PM). The scavenging losses also result in high levels of raw HC. This is in contrast to four-stroke engines that use the crankcase as an oil sump and a pump to distribute oil throughout the engine, resulting in virtually no PM..

We tested 11 four-stroke and three two-stroke ATVs over the FTP. Tables 4.4-1 and 4.4-2 shows that the HC emission rate for the four-stroke ATVs is significantly lower than for the two-stroke ATVs, whereas the NOx emissions from the two-strokes were considerably lower than from the four-strokes. The CO emissions were also lower for the two-stroke ATVs. The four-stroke ATVs that we tested that had high levels of CO also happened to be 50-state certified vehicles, meaning they are California vehicles sold nationwide. Because there are California standards for HC+NOx, manufacturers have tended to calibrate the ATVs fuel system to run even richer than normal to meet the NOx standard. Since the CO standard in California is relatively high, these ATVs can run rich and still meet the CO standards. Another observation that can be made from the test results is that of the 11 four-stroke models tested, the four ATVs with the lowest emissions were sport models. The other seven models were all utility models. The four sport models, the Yamaha Warrior and Raptor, the Honda 300EX, and Polaris Trail Boss had an average HC+NOx level of 1.35 g/km, below our 1.5 g/km standard, and an average CO level of 28.5 g/km, only slightly above our standard of 25 g/km. In fact, the Warrior and Raptor already meet our standards with considerable headroom. The average HC+NOx and CO emissions levels for the seven utility models were 2.20 g/km and 33.7 g/km, respectively. This may indicate that when testing over the highway motorcycle test procedure, utility ATVs may be at a disadvantage compared to the sport models because of their lower power-to-weight ratio and use of continuously variable transmissions. Even when tested over the less strenuous Class I highway motorcycle test cycle, the utility ATVs appeared to be operating at higher loads than the sport models. Although we didn’t examine all of the ATVs, the Warrior operated at a slightly leaner air and fuel mixture than the Polaris Sportsman. This could be model or manufacturer specific, but if this is at all indicative of how sport and utility ATVs fuel systems are calibrated, the fact that utility ATVs already operate very rich could be exacerbated when operated over the FTP, resulting in the higher HC and CO levels that we observed.

Table 4.4-1
Four-Stroke ATV Emissions (g/km)

Make	Model	Model Year	Eng. Displ.	HC	CO	NOx
Kawasaki	Bayou	1989	280 cc	1.17	14.09	0.640
Honda	300EX	1997	298 cc	1.14	34.60	0.155
Polaris	Trail Boss	1998	324 cc	1.56	43.41	0.195
Yamaha	Warrior	1998	349 cc	0.98	19.44	0.190
Polaris	Sportsman	2001	499 cc	2.68	56.50	0.295
Arctic Cat	375 Automatic	2001	375 cc	1.70	49.70	0.190
Yamaha	Big Bear	2001	400 cc	2.30	41.41	0.170
Honda	Rancher	2001	400 cc	1.74	33.98	0.150
Bombardier	4X4 AWD	2001	500 cc	1.62	20.70	0.740
Polaris	Sportsman	2001	499 cc	1.56	19.21	0.420
Yamaha	Raptor	2001	660 cc	0.97	16.56	0.210
Average				1.58	31.78	0.305

Table 4.4-2
Two-Stroke ATV Emissions (g/km)

Make	Model	Model Year	Eng. Displ.	HC	CO	NOx
Suzuki	LT80	1998	79 cc	7.66	24.23	0.047
Polaris	Scrambler	2001	89 cc	38.12	25.08	0.057
Polaris	Trailblazer	2000	250 cc	18.91	44.71	0.040
Average				21.56	31.34	0.048

4.4.2 Potentially Available ATV Technologies

A variety of technologies are currently available or in stages of development to be available for use on two-stroke ATVs, such as engine modifications, improvements to carburetion (improved fuel control and atomization, as well as improved production tolerances), enleanment strategies for both carbureted and fuel injected engines, and semi-direct and direct fuel injection. However, it is our belief that manufacturers will choose to convert their two-stroke engines to four-stroke applications, because of the cost and complexity of the above mentioned technologies necessary to make a two-stroke engine meet our standards. We believe that to meet our ATV standards, manufacturers will use four-stroke engines. Depending on the size, performance and calibration of the engine, they will also need to make improvements to the fuel system, consisting of improved carburetor tolerances and a leaner air and fuel mixture, and in some cases the use of pulse air injection.

4.4.2.1 Engine Modifications

There are a variety of engine modifications that could reduce emissions from two-stroke and four-stroke engines. The modifications generally either increase trapping efficiency (i.e., reduce fuel short-circuiting) or improve combustion efficiency. Those modifications for two-stroke engines that increase trapping efficiency include optimizing the intake, scavenge and exhaust port shape and size, and port placement, as well as optimizing port exhaust tuning and bore/stroke ratios. Optimized combustion charge swirl, squish and tumble would serve to improve the combustion of the intake charge for both two- and four-stroke engines. Manufacturers have indicated that they believe these modifications for two-stroke engines have the potential to reduce emissions by up to 40 percent, depending on how well the unmodified engine is optimized for these things, but would be insufficient alone to meet our standards[y].

4.4.2.2 Carburetion Improvements

There are several things that can be done to improve carburetion in ATV engines. First, strategies to improve fuel atomization would promote more complete combustion of the fuel/air mixture. Additionally, production tolerances could be improved for more consistent fuel metering. Both of these things would allow for more accurate control of the air/fuel ratio. In conjunction with these improvements in carburetion, the air/fuel ratio could be leaned out some. ATV engines are currently calibrated with rich air/fuel ratios for durability and performance reasons. According to manufacturers, based on their experience, leaner calibrations could serve to reduce CO and HC emissions by up to 20 percent, depending on how lean the unmodified engine is prior to recalibration[z]. Small improvements in fuel economy could also be expected with recalibration.

The calibration changes just discussed (as well as some of the engine modifications previously discussed) could create concerns about ATV engine durability. There are many engine improvements that could be made to regain any lost durability that occurs with leaner calibration. These include changes to the cylinder head, pistons, pipes and ports for two-stroke and valves for four-stroke, to reduce knock. In addition, critical engine components could be made more robust with improvements such as better metallurgy to improve durability.

[y] See “Memo to Docket on Technical Discussions with Recreational Vehicle Manufacturers,” from Linc Wehrly. Docket A-2000-01, IV-B-43.

[z] See “Memo to Docket on Technical Discussions with Recreational Vehicle Manufacturers,” from Linc Wehrly. Docket A-2000-01, IV-B-43.

The same calibration changes to the air/fuel ratio just discussed for carbureted engines could also be employed, possibly with more accuracy, with the use of fuel injection. At least one ATV manufacturer currently employs electronic fuel injection on one of its ATV models.

4.4.2.3 Direct and Semi-Direct Fuel Injection

In addition to rich air/fuel ratios, one of the main reasons that two-stroke engines have such high levels of HC emissions is scavenging losses, as described above. One way to reduce or eliminate such losses is to inject the fuel into the cylinder after the exhaust port has closed. This can be done by injecting the fuel into the cylinder through the transfer port (semi-direct injection) or directly into the cylinder (direct injection). Both of these approaches are currently being used successfully in two-stroke personal watercraft engines and some are showing upwards of 70 percent reductions in emissions. Direct injection is also being used by some motorcycle manufacturers (e.g., Aprilla) on small mopeds, scooters, and motorcycles to meet emission standards for two-strokes in Europe and Asia. A new start-up company called Rev! Motorcycles plans to manufacturer high-performance recreational and competition off-highway motorcycles with direct fuel injection two-stroke engines in the next year or so (for more, see Section 4.7.2.3). They have not indicated whether they will manufacturer any ATVs. Substantial improvements in fuel economy could also be expected with these technologies. However, there are some issues with ATV operation (larger displacement engines that experience more transient operation than watercraft and small mopeds) that make the application of the direct injection technologies somewhat more challenging for ATVs than for personal watercraft and small displacement scooters. The biggest obstacle for this technology is that the many of the two-stroke equipped ATVs are youth models which emphasize low price. Direct injection is relatively expensive and may not be considered to be cost effective for these engines.

4.4.2.4 Four-Stroke Engines

Four-stroke engines produce significantly lower levels of HC emissions than two-stroke engines. This is primarily due to the fact that two-stroke engines experience high scavenging losses that allow up to a third of the unburned air and fuel mixture to escape into the atmosphere during the combustion process. Since four-stroke engines have a valve-train system and introduce the air and fuel mixture into the combustion chamber when the exhaust valve is closed or almost closed, there is very little scavenging of unburned fuel. Thus, four-stroke engines have superior HC control to conventional two-stroke engines. Four-stroke engines have comparable CO performance to two-stroke engines. CO emissions result from incomplete combustion due to an excess of fuel in the air and fuel mixture. Thus, CO emissions are a function of air and fuel mixture. Current unregulated four-stroke and two-stroke engines both operate with a rich air and fuel mixture, resulting in high levels of CO emissions. Therefore, four-stroke engines do not have inherently low CO emission levels. Four-stroke engines also generate higher NOx emission levels than two-stroke engines. This is because NOx emissions are a function of temperature. Higher combustion temperatures generate higher NOx emission levels. Four-stroke engines have more complete combustion than conventional two-stroke engines, which results in higher combustion temperatures and higher NOx emission levels. Thus, four-stroke engines are an excellent choice for significantly reducing HC emissions. However, to reduce CO emissions, a four-stroke engine may need some fuel system calibration changes, engine modifications, or the use of secondary air or a catalyst. To reduce NOx emissions from a four-stroke engine would require fuel system calibration changes, engine modifications, exhaust gas recirculation (EGR), or a catalyst.

Since 80 percent of all ATVs sold each year are four-stroke, there is no question about the feasibility of using four-stroke engine technology for ATVs. Conversion from two-stroke to four-stroke engine technology also results in improvements to fuel consumption and engine durability. These benefits could be especially valuable to consumers who purchase utility ATVs.

The ATV models that are currently equipped with two-stroke engines tend to be small-displacement youth models, entry-level adult ATVs and high-performance adult sport ATVs. While most youth ATVs are equipped with two-stroke engines, there are several manufactures who offer four-stroke models. Youth ATVs are regulated by the Consumer Product Safety Commission (CPSC). Although the regulations are voluntary, manufacturers take them very seriously, and one of the their requirements is that youth ATV speeds be governed. For "Y6" ATVs (i.e., age 6 and up) the maximum speed is 15 miles per hour (mph) and for "Y12" ATVs (i.e., age 12 and up), the maximum speed is 30 mph. By Consent Decree these are limited to 50 cc and 90 cc, respectively. Some manufacturers have argued that because of these constraints, they need to use light-weight two-stroke engines, which have higher power-to-weight ratios than four-stroke engines, in order to have sufficient power to operate the ATV. However, as mentioned earlier, some manufacturers already use four-stroke engines in these applications without any problem. The power required to meet the maximum speed limits for these little ATVs is low enough that a four-stroke engine is more than adequate. The real issue appears to be cost. Manufacturers argue that youth ATVs are price sensitive and that minor increases in cost would be undesirable. Four-stroke engines are more expensive than similarly powered two-stroke engines. This appears to be the issue with entry-level adult ATVs as well. Those manufacturers that offer two-stroke entry-level ATVs also offer similar entry-level machines with four-stroke engines. The argument is that consumers of their product like having the ability to choose between engine types. In addition, manufacturers have expressed concern that these smaller engines have lower cylinder surface to volume area ratios than larger displacement engines, thus increasing the difficulty of in-cylinder control of HC emissions. That is one of the reasons that we 1) are allowing engines under 99 cc to stay in the relatively less stringent utility engine program and 2) that we permit averaging across the entire spectrum of ATV vehicles/engines if they certify to the FTP-based standards.

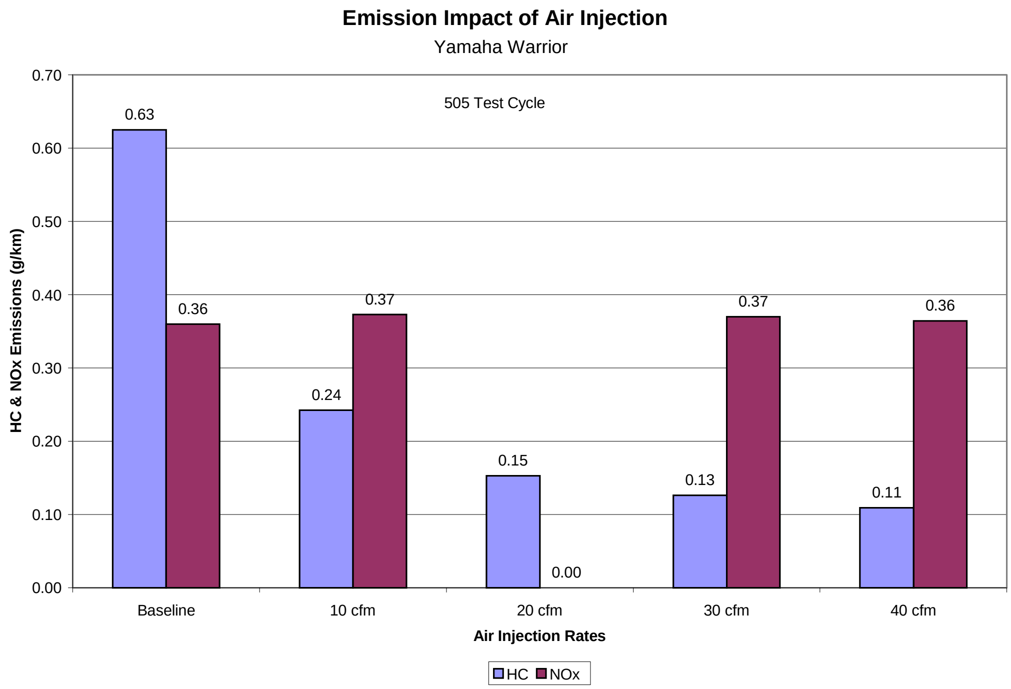
Adult sport ATVs equipped with two-stroke engines were at one time considered the only ATVs that were capable of providing true high-performance. However, advancements in four-stroke engine technology for ATVs and off-highway motorcycles have now made it possible for larger displacement high-powered four-stroke engines to equal, and in some cases surpass, the performance of the high-powered two-stroke engines. Again, the argument for two-stroke engines appears to be a matter of choice for consumers. However, since only two manufacturers produce two-stroke adult ATVs, we believe that the relatively low sales volumes for these models will make it cost prohibitive to reduce two-stroke emissions to the levels necessary to meet our standards. Nonetheless, the credit exchange program (ABT) we are including for ATV s creates the possibility for manufacturers to retain some lower emission two-stroke ATVs and offset their higher emissions with reductions from 4-stroke models.

4.4.2.5 Air Injection

Secondary pulse air injection involves the introduction of fresh air into the exhaust pipe immediately after the exhaust gases exit the engine. The extra air causes further combustion to occur as the gases pass through the exhaust pipe, thereby oxidizing more of the HC and CO that escape the combustion chamber. This type of system is relatively inexpensive and uncomplicated because it does not require an air pump; air is drawn into the exhaust through a one-way reed valve due to the pulses of negative pressure inside the exhaust pipe. Secondary pulse-air injection is one of the most effective non-catalytic, emissions control technologies; compared to engines without the system, reductions of 30-70% for HC and 30-80% for CO are possible with pulse-air injection.

This technology is fairly common on highway motorcycles and is used on some off-highway motorcycle models in California to meet the California off-highway motorcycle and ATV emission standards. We believe that secondary air injection will not be necessary to meet our standards for all models, but will be a viable control technology for some machines. We tested three different four-stroke ATVs with secondary air. A 1998 Yamaha Warrior sport model, a 2001 Polaris Sportsman High Output (H.O.) utility model, and a 2001 Polaris Sportsman utility model. Initially we didn't have access to a pulse air system so we used shop air introduced into the exhaust manifold at various flow rates to simulate air injection. To save time and money, we performed our tests over the hot 505 section of the Class I Motorcycle cycle. This is a warmed-up version of the first bag or 505 seconds of the FTP test cycle. The initial tests with shop air indicated that air injected into the exhaust stream could reduce HC emissions from 5-percent to 60-percent depending on the vehicle and the amount of air injected. For example, the Warrior was very responsive to air injection. We tested at flow rates of 10, 20, 30, and 40 cubic feet per minute (cfm). HC emissions were reduced from 25-percent to 60-percent depending on the flow rate. Figure 4.4-1 illustrates these reductions. We also experimented with the air and fuel mixture and found that if we leaned the mixture slightly, the air injection had an even greater effect, reducing HC emissions by 83-percent from the uncontrolled baseline level with 40 cfm of air. Our next task was to determine how the various flow rates we tested compared to the capabilities of a pulse air system. A pulse air system uses a system of check valves which uses the normal pressure pulsations in the intake manifold to draw in air from outside and inject into the exhaust manifold. A reed valve is used in the exhaust manifold to prevent reverse airflow of exhaust gases through the system. A valve called the "air injection" valve reacts to high intake manifold vacuum and will cut-off the supply of air during engine decelerations, thereby preventing after burn in the exhaust system.

Figure 4.4-1



Since generic pulse air systems can't be simply purchased from the store or dealership, we had to modify an existing pulse air system to work on our test ATVs. We purchased a pulse air system for a 1995 BMW 100R. Because this is a multi-cylindered engine, we had to make some modifications to get it to work with a single-cylinder ATV engine. We were able to successfully install the pulse air system onto the Warrior and performed several hot 505 test runs to see how the pulse air system compared with the various flow rates of shop air. For our shop air tests, we injected a constant flow rate over the entire 505 seconds of the test. Because a pulse air system relies on drawing air into the exhaust system during negative pressure pulses in the cylinder, increasing the engine speed increases the magnitude of the positive pressure pulses resulting in increased back-pressure which can make a pulse air system ineffective. Our biggest concern was that a pulse air system might not have the same overall flow capacity as our shop air experiments since the pulse air system is only capable of drawing air into the exhaust manifold during lower speeds where increased exhaust back-pressure is decreased. Due to timing constraints, we only tested the Warrior with the pulse air system in conjunction with the enleaned carburetor setting. The carburetor was enleaned by raising the jet needle one clip notch. When we raised the clip two notches, the engine ran too lean and performance and driveability were affected. With pulse air and the slightly lean calibration, the Warrior had emissions comparable to the 20-30 cfm shop air results. Figure 4.4-2 shows the results between shop air and the pulse air results. When the Warrior was tested over the full FTP with pulse air and the slightly lean calibration, HC and CO emissions were reduced from baseline levels, while NOx increased. HC was reduced by 73-percent, CO was reduced by 83-percent and NOx was increased by 47-percent. The NOx emission increase is most likely due to the leaner air and fuel mixture. The HC+NOx level was reduced by 54-percent from the baseline level as shown in Table 4.4-3.

Figure 4.4-2

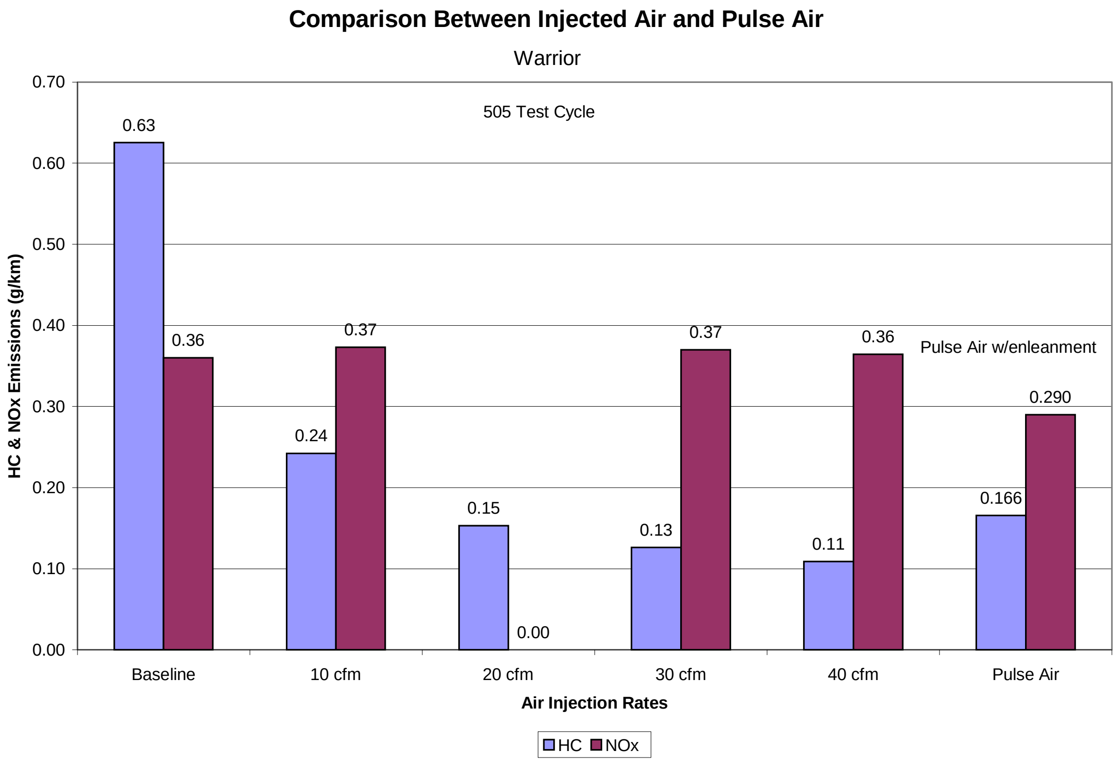


Table 4.4-3
Yamaha Warrior Emissions with and without Pulse Air Injection

Test Configuration	HC	CO	NOx	HC+NOx
Baseline	0.98	19.44	0.19	1.17
Pulse Air w/enleanment	0.26	3.33	0.28	0.54

The two Polaris Sportsman models proved to be more problematic than the Warrior. As discussed above, the utility ATVs all had higher baseline emissions levels than the sport models. The Polaris Sportsman High Output (H.O.) had the highest baseline emissions of any of the ATVs we tested. HC+NOx emissions were 3.0 g/km, almost 100-percent higher than our standard of 1.5 g/km, while CO was 56.5 g/km, 125-percent higher than the standard of 25 g/km. The regular Sportsman was cleaner than the H.O. model with a HC+NOx level of 1.98 g/km and a CO level of 19.2 g/km. As a result of these higher baseline emissions, the two Sportsman models were at a disadvantage compared to the relatively clean Warrior. When supplying shop air to the two Sportsman models we saw varied results. The higher emitting H.O. model responded to air injection. However, the emissions were still so high that we stopped any further testing and focused on catalyst use for this model. The regular Sportsman model was less receptive to air injection. In fact the same levels of flow that resulted in sharp reductions for the Warrior had only minimal effects for this vehicle. Further investigation indicated that the air and fuel mixture was too rich for the injected air to have any significant effect. We tried to lean-out the air and fuel mixture by raising the jet needle clip to the top of the needle, similar to what we did for the Warrior, but there was no response. We had to use a different, leaner main jet, in order to successfully lean-out the air and fuel mixture. With the air and fuel mixture leaner, we ran several tests with shop air and found that the Sportsman was more receptive to air injection, so we decided to install the BMW pulse air system that we modified for the Yamaha Warrior to the Sportsman. We ran a full FTP with the pulse air system and the leaner main jet installed and found that emissions were reduced considerably. HC and CO were reduced by 71-percent and 68-percent, respectively. NOx emissions increased by 45-percent. Limited time prevented us from further investigating ways to reduce the air and fuel mixture. However, as Table 4.4-4 shows, the Sportsman was able to meet the standard using this approach.

Table 4.4-4
Polaris Sportsman Emissions with and without Pulse Air Injection

Test Configuration	HC	CO	NOx	HC+NOx
Baseline	1.56	19.21	0.42	1.98
Pulse Air w/enleanment	0.49	6.12	0.60	1.09

4.4.2.6 Catalyst Technology

For our proposal, we proposed Phase 2 standards of 1.0 g/km HC+NOx. To achieve a standard of 1.0 g/km, manufacturers will actually have to design their emission control system to meet an emission level lower than the standard to account for deterioration and provide an acceptable certification emission margin. Manufactures typically aim for a certification emissions margin of 20 percent. Our NONROAD emission model uses a deterioration factor of 1.17 for four-stroke ATV engines. Taking these factors into consideration would result in a potential emission level design goal of approximately 0.7 g/km. To meet this level of HC+NOx control, we projected in our proposal that it might be necessary for some ATV models to use a catalyst. To establish the feasibility of using a catalyst on an ATV, we tested the Polaris Sportsman High Output (HO) ATV equipped with several different catalysts. The Sportsman is a large utility ATV equipped with a 500 cc (HO) four-stroke engine and is one of the larger ATV models currently offered in the market. We chose this model to demonstrate catalyst viability because, as mentioned above, it had the highest baseline emissions of any of the ATVs we tested, and it is a California certified vehicle that is sold nationwide. We tested the Polaris with three different catalysts. Two of the catalysts were three-way catalysts with metal substrates and cell densities of 200 cells/in^2 . One of the catalyst's had a Pt/Rh washcoat, while the other used a Pd-only washcoat. The third catalyst was an oxidation catalyst with a ceramic substrate and a cell density of 400 cells/in^2. Table 4.4-5 shows that emissions were significantly reduced when the various catalysts were installed on the Sportsman. However, even though there was a significant reduction in emissions, the ATV was still unable to meet the proposed 1.0 g/km HC+NOx standard, let alone the design target of approximately 0.7 g/km.

Table 4.4-5
Polaris Sportsman 500 Emissions with Various Catalysts

Catalyst	HC	CO	NOx	HC+NOx
Baseline	2.68	56.5	0.3	2.98
TWC (Pd-only)	1.27	35.27	0.05	1.32
TWC (Pt/Rh)	1.29	32.6	0.04	1.33
Oxidation	1.38	28.87	0.02	1.4

The three catalysts that we used had volumes ranging from 400 to 500 cc. Most highway motorcycles typically use catalysts with a catalyst-to-engine volume ratio of one half. In other words, they typically use a catalyst that has a volume approximately half of the engine's displacement. For our catalyst cost estimation in the proposal, we argued that this would be a good assumption for ATVs as well. We estimated that for ATVs, the catalyst size necessary to meet our proposed HC+NOx standard of 1.0 g/km would be equal to half of the engine displacement. We projected an average catalyst volume of 200 cc. The catalysts that we tested were roughly double the size of catalysts we projected would be necessary to meet our standards. We chose to use these catalysts not because of their size, but because of their availability. All three catalysts are used in production highway motorcycle applications and were provided to us by catalyst manufacturers. The highway motorcycles that these catalyst are from have an engine displacement of approximately 900 cc. The implication of this is that even with catalysts twice as large as we projected would be necessary to meet our 1.0 g/km standard, the emission reductions for this ATV were still about 33-percent short of the standard.

Due to rulemaking schedule constraints, we had limited time to perform the testing and analyses that we felt were necessary to support the proposed standards. One of the consequences of this timing was that were unable to test the Sportsman with the various catalysts with pulse air injection and a leaner air and fuel mixture. It is quite possible, that had we been able to perform those tests we would have found that the emissions from the Sportsman could be brought down to levels below the proposed Phase 2 standards. However, with our limited success with air injection and enleaning of the air and fuel mixture with the two Sportsman models, it is also possible that these additional strategies would not have helped quickly. We are confident that the use of a catalyst has the potential to significantly reduce emissions for many ATV applications, but at this time we can not confidently claim they will work for all applications without further investigation.

4.4.3 Test Cycle/Procedure

For ATVs, we specify the current highway motorcycle test procedure for measuring emissions. The highway motorcycle test procedure is the same test procedure as used for light-duty vehicles (i.e., passenger cars and trucks) and is referred to as the Federal Test Procedure (FTP). The FTP for a particular class of engine or equipment is actually the aggregate of all of the emissions tests that the engine or equipment must meet to be certified. However, the term FTP has also been used traditionally to refer to the exhaust emission test based on the Urban Dynamometer Driving Schedule (UDDS), also referred to as the LA4 (Los Angeles Driving Cycle #4). The UDDS is a chassis dynamometer driving cycle that consists of numerous "hills" which represent a driving event. Each hill includes accelerations, steady-state operation, and decelerations. There is an idle between each hill. The FTP consists of a cold start UDDS, a 10 minute soak, and a hot start. The emissions from these three separate events are collected into three unique bags. Each bag represents one of the events. Bag 1 represents cold transient operation, bag 2 represents cold stabilized operation, and bag 3 represents hot transient operation.

Highway motorcycles are divided into three classes based on engine displacement, with Class I (50 to 169 cc) being the smallest and Class III (280 cc and over) being the largest. The highway motorcycle regulations allow Class I motorcycles to be tested on a less severe UDDS cycle than the Class II and III motorcycles. This is accomplished by reducing the acceleration and deceleration rates on some the more aggressive "hills" and by reducing the top speed from 56 miles per hour to 35 mile per hour. California requires ATVs to be tested over the Class I motorcycle cycle. Our testing has shown that some utility ATVs are at a disadvantage when tested over the Class II and III cycles because utility ATVs use continuously variable transmissions (CVT), similar to snowmobiles. These transmissions tend to be geared towards lower speed operation for ATVs with high torque generation at lower engine speeds. This is so they can perform a broad variety of utilitarian tasks, such as plowing snow, hauling loads, cutting grass and other high load activities. As a result, when operated over the Class II or III motorcycle test cycle, these vehicles operate under a much higher load than would be typically expected in real-world operating conditions. Operating under higher loads means the engine runs at a richer air and fuel mixture and generates higher levels of emissions. We received comments from manufacturers stating that if keep the FTP as the main ATV test cycle, that we should only require the Class I cycle, similar to California. As a result of these comments and our own experience testing various ATVs over the FTP, we have decided to require Class I motorcycle test cycle rather than using all three cycles depending on the engine displacement as proposed.

Some manufacturers have noted that they do not currently have chassis-based test facilities capable of testing ATVs. Manufacturers have noted that requiring chassis-based testing for ATVs would require them to invest in additional testing facilities which can handle ATVs, since ATVs do not fit on the same chassis dynamometer roller(s) as motorcycles used in chassis testing. Some manufacturers also have stated that low pressure tires on ATVs would not stand up to the rigors of a chassis dynamometer test. California provides manufacturers with the option of certifying ATVs using the engine-based, utility engine test procedure (SAE J1088), and most manufacturers use this option for certifying their ATVs. Manufacturers have facilities to chassis test motorcycles and therefore California does not provide an engine testing certification option for off-highway motorcycles.

We have tested numerous ATVs over the FTP and have found that several methods can be used to test ATVs on chassis dynamometers. The most practical method for testing an ATV on a motorcycle dynamometer is to disconnect one of the drive wheels and test with only one drive wheel in contact with the dynamometer. For chassis dynamometers set-up to test light-duty vehicles, wheel spacers or a wide axle can be utilized to make sure the drive wheels fit the width of the dynamometer. We have found that the low pressure tires have withstood dynamometer testing without any problems.

We acknowledge that a chassis dynamometer could be costly to purchase and difficult to put in place in the short run, especially for some smaller manufacturers. ATV manufacturers may therefore certify using the J1088 engine test cycle per the California off-highway motorcycle and ATV program for the model years 2006 through 2008. After 2008, this option expires and the FTP becomes the required test cycle. If manufacturers can develop an alternate transient test cycle (engine or chassis) that shows correlation with the FTP or demonstrates representativeness of actual ATV operation greater than the FTP, then, through rulemaking, we would consider allowing the option of an alternative test cycle in place of the FTP.

4.4.4 Small Displacement Engines

For small displacement ATVs of 70 cc or less, we proposed that they would have the permanent option to certify to the proposed FTP-based ATV standards or meet the Phase 1 Small SI emission standards for non-handheld Class 1 engines. These standards are 16.1 g/kW-hr HC+NOx and 610 g/kW-hr CO. Manufacturers argued that ATVs with engine displacements between 70 cc and 99 cc also should be allowed to certify to the Small SI standards, since the differences between a 70 cc and 99 cc engine is very small and the ATVs equipped with 99 cc engines face the same obstacles with the FTP test cycle as the 70 cc and below ATVs. They also argued that the Phase 1 Small SI standards are too stringent for these engines and recommended that EPA adopt the Phase 2 standards for Class 1B engines of 40 g/kW-hr for HC+NOx and 610 g/kW-hr for CO.

We recognize that the vast majority of engine families, including 4-stroke engines, below 100 cc are not certified to the California standards, which is an indication to us that the standards proposed may not be feasible for most engines in this size range given the lead time provided. However, manufacturers did not provide supporting data and we do not have data to confirm that the level recommended by the manufacturers would result in an appropriate level of control. We examined the 2002 model year certification data for non-handheld Small SI engines certified to the Phase 2 Class I-A and I-B engine standards (engines below 100 cc)and found that the five engine families certified to these standards had average emissions for HC+NOx of about 25 g/kW-hr (see Table 4.4-6). All of these engine families had CO emissions below 500 g/kW-hr and well below the 610 g/kW-hr level recommended by manufacturers.

Table 4.4-6
2002 Certification Data for Non-Handheld Small SI Phase 2 Class I-A and I-B Engines

Manufacturer	Engine Family	Displacement	HC+NOx (g/kW-hr)	CO (g/kW-hr)
Honda	2HNXS.0224AK	22.2	31.6	329.8
MTD Southwest	2MTDS.0264Y2	26.2	14.7	483.2
Honda	2HNXS.0314AK	31.1	41.0	391.4
Honda	2HNXS.0574AK	49.4	25.4	372.1
Honda	2HNXS.0991AK	98.5	13.4	445.3
Average			25.2	404.4

We believe these levels are more representative of the levels that can be achieved with the lead time provided through the use of 4-stroke engines than the standards recommended by the manufacturers. Since we are offering averaging with the HC+NOx standard, a standard based on the average of 25.0 g/kW-hr for the five engine families is appropriate for ATVs with an engine displacement under 99 cc. Since we are not offering an averaging program for CO emissions, it is apparent from the above data that a standard of 400 g/kW-hr would be very difficult for these smaller ATV engines to achieve. Therefore, based on the above data, we believe that a standard of 500 g/kW-hr can be achieved with engines under 99 cc. We believe these standards can be meet through the use of the various technologies described above.

4.4.5 Impacts on Noise, Energy, and Safety

The Clean Air Act directs us to consider potential impacts on noise, energy, and safety when establishing the feasibility of emission standards for nonroad engines.

As automotive technology demonstrates, achieving low emissions from spark-ignition engines can correspond with greatly reduced noise levels. Virtually all ATVs are equipped sound suppression systems or mufflers. The four-stroke engines used in ATVs are considerably more quiet than two-stroke engines. Electronically controlled fuel systems are able to improve management of the combustion event which can further help lower noise levels.

Adopting new technologies for controlling fuel metering and air-fuel mixing will lead to substantial improvements in fuel consumption rates for four-stroke engines. Four-stroke engines have far less fuel consumption than two-stroke engines. Average mileage for a baseline two-stroke ATV is 20-25 mpg, while the average four-stroke ATV gets 30-50 mpg.

We believe the technology discussed here would have no negative impacts on safety. Four-stroke engine technology has been utilized on ATVs for numerous years without any incident. Secondary air and catalysts have been utilized in highway motorcycles and lawn and garden equipment without any safety concerns.

4.4.6 Conclusion

We expect that the ATV emission standards will largely be met through the conversion of two-stroke engines to four-stroke engines and with some minor carburetor calibration modifications and air-fuel ratio enleanment, combined with some use of pulse air injection for the four-stroke engines which now dominate this market. Our test data indicates that ATVs can have a wide variety of emissions performance. Some models are very clean and will require a relatively minor improvement to meet our standards. Other ATVs, especially larger heavier utility models, will require substantially more work. Our development testing indicates that control strategies such as carburetor enleanment and pulse air injection can significantly reduce emissions. In particular, these strategies are a path to allow most ATV models to meet a HC+NOx standard of 1.5 g/km with due consideration to useful life requirements and compliance margins most manufacturers adopt for various reasons. The other main control strategy that we examined was the use of catalysts. While it is well known that catalysts can significantly reduce exhaust emissions, the results that we had in our testing program fell short of complete success. For numerous reasons, including lack of time and hardware, we were unsuccessful at getting all of our test ATVs to meet our proposed HC+NOx standard of 1.0 g/km. We believe further investigation is warranted. However, due to scheduling concerns, we did not have the time to complete this investigation. As a result, we have decided to postpone the setting of phase 2 standards at this time. We plan to continue to investigate the emission reduction capabilities of ATVs and may establish a second phase of standards in the future.

We are confident that control strategies such as the use of a four-stroke engine with carburetor enleanment and pulse air injection can easily meet our HC+NOx emission standard of 1.5 g/km even with a 20-percent headroom to accommodate production variability and deterioration by the 2006 model year. That is why we are, for now, establishing a single set of standards for ATVs of 1.5 g/km HC+NOx and 25 g/km CO. These technologies have been utilized in a number of different applications, such as highway motorcycles, personal watercraft, lawn and garden equipment, and small scooters. These technologies also have potential benefits beyond emission reductions (e.g., improved fuel economy, reliability and performance, and reduced noise).

4.5 Off-Highway Motorcycles

The following paragraphs summarize the data and rationale supporting the emission standards for off-highway motorcycles, which are listed in the Executive Summary.

4.5.1 Baseline Technology and Emissions

Off-highway motorcycles are similar in appearance to highway motorcycles, but there are several important distinctions between the two types of machines. Off-highway motorcycles are not street-legal and are primarily operated on public and private lands over trails and open land. Off-highway motorcycles tend to be much smaller, lighter and more maneuverable than their larger highway counterparts. They are equipped with relatively small-displacement single-cylinder two- or four-stroke engines ranging from 50 to 650 cubic centimeters (cc). The exhaust systems for off-highway motorcycles are distinctively routed high on the frame to prevent damage from brush, rocks, and water. Off-highway motorcycles are designed to be operated over varying surfaces, such as dirt, sand, and mud, and are equipped with knobby tires which provide better traction in off-road conditions. Unlike highway motorcycles, off-highway motorcycles have fenders mounted far from the wheels and closer to the rider to keep dirt and mud from spraying the rider and clogging between the fender and tire. Off-highway motorcycles are also equipped with a more advanced suspension system than those for highway motorcycles. This allows the operator to ride over obstacles and make jumps safely. This advanced suspension system tends to make off-highway motorcycles much taller than highway motorcycles, in some cases up to a foot taller.

Thirty percent of off-highway motorcycle sales are generally considered to be competition motorcycles. The vast majority of competition off-highway motorcycles are two-strokes. The CAA requires us to exempt from our regulations vehicles used for competition purposes. The off-highway motorcycles that remain once competition bikes are excluded are recreational trail bikes and small-displacement youth bikes. The majority of recreational trail bikes are equipped with four-stroke engines. Youth off-highway motorcycles are almost evenly divided between four-stroke and two-stroke engines.

The fuel system used on off-highway motorcycles, whether two- or four-stroke, are almost exclusively carburetors, although at least one manufacturer has introduced a four-stroke off-highway motorcycle with electronic fuel injection. Although many off-highway motorcycles are four-stroke equipped, they still can have relatively high levels of HC and extremely high levels of CO, because many of them operate with a "rich" air and fuel mixture, which enhances performance and allows engine cooling which promotes longer engine life. This is also true for two-stroke equipped off-highway motorcycles. Rich operation results in high levels of HC, CO, and PM emissions. In addition, two-stroke engines lubricate the piston and crankshaft by mixing oil with the air and fuel mixture. This is accomplished by most contemporary two-stroke engines with a pump that sends two-cycle oil from a separate oil reservoir to the carburetor where it is mixed with the air and fuel mixture. Some less expensive two-stroke engines require that the oil be mixed with the gasoline in the fuel tank. Because two-stroke engines tend to have high scavenging losses, where up to a third of the unburned air and fuel mixture goes out of the exhaust, lubricating oil particles are also released into the atmosphere, becoming HC particles or particulate matter (PM). The scavenging losses also result in high levels of raw HC. This is in contrast to four-stroke engines that use the crankcase as an oil sump and a pump to distribute oil throughout the engine, resulting in virtually no PM.

We tested six high-performance two-stroke motorcycles and four high-performance four-stroke motorcycles over the FTP. Tables 4.5-1 and 4.5-2 shows that the HC emissions for the four-stroke bikes is significantly lower than for the two-stroke bikes, whereas the NOx emissions from the two-strokes were a bit lower. The CO levels were also considerably lower for the four-stroke bikes.

Table 4.5-1
Four-Stroke Off-Highway Motorcycles Emissions (g/km)

Make	Model	Model Year	Eng. Displ.	HC	CO	NOx
Yamaha	WR250F	2001	249 cc	1.46	26.74	0.110
Yamaha	WR400F	1999	398 cc	1.07	20.95	0.155
KTM	400EXC	2001	398 cc	1.17	28.61	0.050
Husaberg	FE501	2001	498 cc	1.30	25.81	0..163
Average				1.25	25.52	0.109

Table 4.5-2
Two-Stroke Off-Highway Motorcycles Emissions (g/km)

Make	Model	Model Year	Eng. Displ.	HC	CO	NOx
KTM	125SX	2001	124 cc	33.77	31.00	0.008
KTM	125SX	2001	124 cc	61.41	32.43	0.011
KTM	200EXC	2001	198 cc	53.09	39.89	0.025
KTM	250SX	2001	249 cc	62.89	49.29	0.011
KTM	250EXC	2001	249 cc	59.13	40.54	0.016
KTM	300EXC	2001	398 cc	47.39	45.29	0.012
Average				52.95	39.74	0.060

4.5.2 Potentially Available Off-Highway Motorcycle Technologies

A variety of technologies are currently available or in stages of development to be available for use on two-stroke off-highway motorcycles, such as engine modifications, improvements to carburetion (improved fuel control and atomization, as well as improved production tolerances), enleanment strategies for both carbureted and fuel injected engines, and semi-direct and direct fuel injection. However, it is our belief that manufacturers will, in most cases, choose to convert their two-stroke engines to four-stroke applications, because of the cost and complexity of the above mentioned technologies necessary to make a two-stroke engine meet our standards. For our standards, we believe that a four-stroke engine with minor improvements to carburetion and enleanment strategies will be all that is required. Each of these is discussed in the following sections.

4.5.2.1 Engine Modifications

There are a variety of engine modifications that could reduce emissions from two-stroke and four-stroke engines. The modifications generally either increase trapping efficiency (i.e., reduce fuel short-circuiting) or improve combustion efficiency. Those modifications for two-stroke engines that increase trapping efficiency include optimizing the intake, scavenge and exhaust port shape and size, and port placement, as well as optimizing port exhaust tuning and bore/stroke ratios. Optimized combustion charge swirl, squish and tumble would serve to improve the combustion of the intake charge for both two- and four-stroke engines. Manufacturers have indicated that these modifications for two-stroke engines have the potential to reduce emissions by up to 40 percent, depending on how well the unmodified engine is optimized for these things, but would be insufficient alone to meet our standards[aa].

4.5.2.2 Carburetion Improvements

There are several things that can be done to improve carburetion in off-highway motorcycle engines. First, strategies to improve fuel atomization would promote more complete combustion of the fuel/air mixture. Additionally, production tolerances could be improved for more consistent fuel metering. Both of these things would allow for more accurate control of the air/fuel ratio. In conjunction with these improvements in carburetion, the air/fuel ratio could be leaned out some. Off-highway motorcycle engines are currently calibrated with rich air/fuel ratios for durability and performance reasons. According to manufacturers, leaner calibrations would serve to reduce CO and HC emissions by up to 20 percent, depending on how lean the unmodified engine is prior to recalibration[bb]. Small improvements in fuel economy could also be expected with recalibration.

The calibration changes just discussed (as well as some of the engine modifications previously discussed) could create concerns about off-highway motorcycle engine durability. There are many engine improvements that could be made to regain any lost durability that occurs with leaner calibration. These include changes to the cylinder head, pistons, pipes and ports for two-stroke and valves for four-stroke, to reduce knock. In addition, critical engine components could be made more robust with improvements such as better metallurgy to improve durability.

Carburetion improvements alone will not allow manufacturers to meet our standards,

[aa] See "Memo to Docket on Technical Discussions with Recreational Vehicle Manufacturers," from Linc Wehrly. Docket A-2000-01, IV-B-43.

[bb] See "Memo to Docket on Technical Discussions with Recreational Vehicle Manufacturers," from Linc Wehrly. Docket A-2000-01, IV-B-43.

especially for two-stroke engines. Carburetion improvements with four-stroke engines may be necessary.

The same calibration changes to the air/fuel ratio just discussed for carbureted engines could also be employed, possibly with more accuracy, with the use of fuel injection. At least one off-highway motorcycle manufacturer currently employs electronic fuel injection on one of its models.

4.5.2.3 Direct and Semi-Direct Fuel Injection

In addition to rich air/fuel ratios, one of the main reasons that two-stroke engines have such high levels of HC emissions is scavenging losses, as described above. One way to reduce or eliminate such losses is to inject the fuel into the cylinder after the exhaust port has closed. This can be done by injecting the fuel into the cylinder through the transfer port (semi-direct injection) or directly into the cylinder (direct injection). Both of these approaches are currently being used successfully in two-stroke personal watercraft engines and some are showing upwards of 70 percent reductions in emissions. Direct injection is also being used by some motorcycle manufacturers (e.g., Aprilla) on small mopeds, scooters, and motorcycles to meet emission standards for two-strokes in Europe and Asia. As discussed above, a small start-up company called Rev! Motorcycles is planning in the near future to manufacture two-stroke high-performance recreational and competition off-highway motorcycles utilizing direct fuel injection. Rev! claims they will be able to meet our optional HC+NOx standard of 4.0 g/km. They have provided limited data based on computer simulation of what they expect their technology to achieve.[26]

Substantial improvements in fuel economy could also be expected with direct injection. However, there are some issues with off-highway motorcycle operation (larger displacement engines that experience more transient operation than watercraft and small mopeds) that make the application of the direct injection technologies somewhat more challenging for motorcycles than for personal watercraft and small displacement scooters. The biggest obstacle for this technology is that the many of the two-stroke equipped off-highway motorcycles are youth models which emphasize low price. Rev! acknowledges that direct injection is expensive and their motorcycle will have a premium price, but they expressed confidence that the success of their system would attract customers and the cost of the system would eventually go down.

4.5.2.4 Four-Stroke Engines

Four-stroke engines produce significantly lower levels of HC emissions than two-stroke engines. This is primarily due to the fact that two-stroke engines experience high scavenging losses that allow up to a third of the unburned air and fuel mixture to escape into the atmosphere during the combustion process. Since four-stroke engines have a valve-train system and introduce the air and fuel mixture into the combustion chamber when the exhaust valve is closed or almost closed, there is very little scavenging of unburned fuel. Thus, four-stroke engines have superior HC control to conventional two-stroke engines. Four-stroke engines have comparable

CO performance to two-stroke engines. CO emissions result from incomplete combustion due to an excess of fuel in the air and fuel mixture. Thus, CO emissions are a function of air and fuel mixture. Current unregulated four-stroke and two-stroke engines both operate with a rich air and fuel mixture, resulting in high levels of CO emissions. Therefore, four-stroke engines do not have inherently low CO emission levels. Four-stroke engines also generate higher NOx emission levels than two-stroke engines. This is because NOx emissions are a function of temperature. Higher combustion temperatures generate higher NOx emission levels. Four-stroke engines have more complete combustion than conventional two-stroke engines, which results in higher combustion temperatures and higher NOx emission levels. Thus, four-stroke engines are an excellent choice for significantly reducing HC emissions. However, to reduce CO emissions, a four-stroke engine may need some fuel system calibration changes, engine modifications, or the use of secondary air or a catalyst. To reduce Nox emissions from a four-stroke engine would require fuel system calibration changes, engine modifications, exhaust gas recirculation (EGR), or a catalyst.

We expect that the conversion of off-highway motorcycle models utilizing two-stroke engines to four-stroke engines will be the main method of achieving our off-highway motorcycle standards. As with ATVs, the question of feasibility for four-stroke engines in off-highway motorcycles is moot, since more than half of the existing off-highway models are already four-stroke and, in some cases, have been for a long time. Honda has used four-stroke engines in all of their off-highway motorcycles (except for their competition motocross bikes) for over thirty years. In fact, over the last 5 to 10 years, the trend has been to slowly replace two-stroke models with four-stroke engines. Although the California emission standards have had some impact on this trend, it has been minor. Four-stroke engines are more durable, reliable, quieter and get far better fuel economy than two-stroke engines. But probably the single most important factor in the spread of the four-stroke engine has been major advances in weight reduction and performance.

Four-stroke engines typically weigh more than two-stroke engines because they need a valve-train system, consisting of intake and exhaust valves, camshafts, valve springs, valve timing chains and other components, as well as storing lubricating oil in the crankcase. Since a four-stroke engine produces a power-stroke once every four revolutions of the crankshaft, compared to a two-stroke which produces one once every two revolutions, a four-stroke engine of equal displacement to a two-stroke engine produces less power, on the average of 30 percent less. So in the past, off-highway motorcycles that used four-stroke engines tended to use very heavy, large displacement engines, but yet had average power and performance. However, recent breakthroughs in technologies have allowed manufacturers to design off-highway motorcycles that use lighter and stronger materials for the engine and the motorcycle frame. The advanced four-stroke technologies, such as multiple valves, used in some of the high-performance four-stroke highway motorcycles, have found their way onto off-highway motorcycles, resulting in vastly improved performance. The newer four-stroke bikes also tend to have an engine power band or range that is milder of more forgiving than a typical two-stroke bike. Two-stroke bikes tend to run poorly at idle and during low load situations. They also typically generate low levels of torque at low to medium speeds, whereas four-stroke bikes traditionally generate a great deal of low-end and mid-range torque. This is important to off-highway motorcycle riders because it is common when riding off-highway motorcycles on trails or other surfaces to come across obstacles that require slow speed maneuverability. A two-stroke engine that idles poorly and has poor low-end torque can easily stall during these maneuvers, whereas a four-stroke bike excels under these conditions. Current sales figures, as well as articles in off-highway motorcycle trade magazines, indicate that four-stroke off-highway motorcycles are more popular than ever.

4.5.2.5 Air Injection

Secondary pulse air injection involves the introduction of fresh air into the exhaust pipe immediately after the gases exit the engine. The extra air causes further combustion to occur as the gases pass through the exhaust pipe, thereby controlling more of the hydrocarbons that escape the combustion chamber. This type of system is relatively inexpensive and uncomplicated because it does not require an air pump; air is drawn into the exhaust through a one-way reed valve due to the pulses of negative pressure inside the exhaust pipe. Secondary pulse-air injection is one of the most effective non-catalytic, emissions control technologies; compared to engines without the system, reductions of 10-40% for HC are possible with pulse-air injection.

This technology is fairly common on highway motorcycles and is used on some off-highway motorcycle models in California to meet the California off-highway motorcycle and ATV emission standards. We believe that secondary air injection should not be necessary to meet our standards, however, some manufacturers may choose to use it on some four-stroke engine models.

4.5.2.6 Catalyst Technology

We do not believe catalysts will be necessary to meet our standards of 2.0 g/km HC+NOx and 25.0 g/km CO. We did not pursue standards that would require catalyst technology for off-highway motorcycles because we do not believe that potential safety and durability issues with catalysts for off-highway motorcycle applications have been adequately addressed. As discussed above in Section 4.4.2.6, to meet our proposed Phase 2 ATV standard of 1.0 g/km HC+NOx would require a design goal of 0.6 to 0.7 g/km HC+NOx to account for certification compliance margin and emission system deterioration. Although we did not perform any testing of off-highway motorcycles with catalysts, the results from our ATV testing gave us additional concern over the viability of catalysts with off-highway motorcycles. For the Polaris Sportsman (HO), a large 500 cc utility ATV model, we were unable to successfully reduce HC+NOx emissions below 1.3 g/km using a production three-way catalyst from a federally certified 900 cc highway motorcycle. The catalysts were larger in volume, precious metal loading, and physical size than we had initially projected would be necessary for ATVs. The physical size of these catalysts were well beyond what would be considered acceptable for off-highway motorcycle applications.

The highway motorcycle that the production catalysts were from weighs around 450 pounds. Typical four-stroke off-highway motorcycles weigh between 225 and 280 pounds. The exhaust system, and thus the catalyst, were routed low to the ground where the extra weight would be least noticeable. For a four-stroke off-highway motorcycle, the exhaust pipe is routed high on the frame to provide a better center of gravity and keep the exhaust pipe away from water, rocks, logs, and other items that could damage the pipe. Placing such a large catalyst in a four-stroke off-highway motorcycle would pose problems of extra weight and packaging, since it is difficult to find locations in the exhaust pipe to place a large catalyst so that it wouldn't interfere with the rider.

We have concerns about the safety and durability of catalysts in off-highway motorcycle applications. As discussed above, off-highway motorcycles operate in very harsh conditions. They experience extreme shock and jarring that can easily damage a catalyst. It is very common for off-highway motorcycles to come into contact with rocks, logs, stumps, and trees through the course of regular riding activities or accidentally in the form of a crash. The substrate of a catalyst can be very fragile, depending on the material used. We are unaware of any data on the durability of a catalyst under such harsh operating conditions. There currently are no off-highway motorcycle models equipped with a catalyst and we know of no studies performed on the long term durability of a catalyst in an off-highway motorcycle application.

Catalysts operate at very high temperatures which can be a concern for burning the rider or potentially starting a fire in the riding environment that they frequent, such as forests and grassy fields. While heat shields may possibly prevent the rider from burns, there is the problem of where to locate the catalyst so that the catalyst is not in the way of the rider adding concern over potential burns. Off-highway motorcycles are much taller than highway motorcycles. In fact, for some shorter riders they are unable to touch the ground with both feet when straddling their off-highway motorcycle. This can be an additional concern for potential catalyst burns and where to locate the catalyst. Because the motorcycle is so tall, the rider often has to lean to one side or another of the bike to keep their balance when the motorcycle is not moving. It is imperative that the catalyst not be located in a manner that would exacerbate the possibility of burning the rider or interfering with the riders balance when standing still on the motorcycle. There is also a question over the durability of heat shields in these harsh applications. Heat shields used for many highway vehicle applications are not designed for the extreme conditions that these vehicles operate in. Again, we are not aware of any data that demonstrates the effectiveness of catalyst heat shields for off-highway motorcycles.

4.5.3 Test Procedure

For off-highway motorcycles, we specify the current highway motorcycle test procedure for measuring emissions. The highway motorcycle test procedure is the same test procedure as that used for light-duty vehicles (i.e., passenger cars and trucks) and is referred to as the Federal Test Procedure (FTP). The FTP for a particular class of engine or equipment is actually the aggregate of all of the emissions tests that the engine or equipment must meet to be certified. However, the term FTP has also been used traditionally to refer to the exhaust emission test based on the Urban Dynamometer Driving Schedule (UDDS), also referred to as the LA4 (Los Angeles Driving Cycle #4). The UDDS is a chassis dynamometer driving cycle that consists of numerous “hills” which represent a driving event. Each hill includes accelerations, steady-state operation, and decelerations. There is an idle between each hill. The FTP consists of a cold start UDDS, a 10 minute soak, and a hot start. The emissions from these three separate events are collected into three unique bags. Each bag represents one of the events. Bag 1 represents cold transient operation, bag 2 represents cold stabilized operation, and bag 3 represents hot transient operation.

In the California program, highway motorcycles are divided into three classes based on engine displacement, with Class I (50 to 169 cc) being the smallest and Class III (280 cc and over) being the largest. The highway motorcycle regulations allow Class I motorcycles to be tested on a less severe UDDS cycle than the Class II and III motorcycles. This is accomplished by reducing the acceleration and deceleration rates on some the more aggressive “hills.” We are applying this same class/cycle distinction for off-highway motorcycles. In other words, off-highway motorcycles with an engine displacement between 50 and 279 cc (Class I and II) must be tested over the Class I highway motorcycle FTP test cycle. Off-highway motorcycles with engine displacements greater than 280 cc would be tested over the Class III highway motorcycle FTP test cycle.

4.5.4 Impacts on Noise, Energy, and Safety

The Clean Air Act directs us to consider potential impacts on noise, energy, and safety when establishing the feasibility of emission standards for nonroad engines.

As automotive technology demonstrates, achieving low emissions from spark-ignition engines can correspond with greatly reduced noise levels. Virtually all recreational off-highway motorcycles are equipped with sound suppression systems or mufflers. The four-stroke engines used in off-highway motorcycles are considerably more quiet than the two-stroke engines used.

Adopting new technologies for controlling fuel metering and air-fuel mixing will lead to substantial improvements in fuel consumption rates for four-stroke engines. Four-stroke engines have far less fuel consumption than two-stroke engines. Average mileage for a baseline two-stroke off-highway motorcycle is 20-25 mpg, while the average four-stroke off-highway motorcycle gets 45-50 mpg.

We believe the technology discussed here would have no negative impacts on safety. Four-stroke engine technology has been utilized on off-highway motorcycles for numerous years without any incident. Secondary air and catalysts have been utilized in highway motorcycles and lawn and garden equipment without any safety concerns.

4.5.5 Conclusion

We expect that the off-highway motorcycle emission standards will largely be met through the conversion of two-stroke engines to four-stroke engines with some minor carburetor calibration modifications and air-fuel ratio enleanment for some four-strokes. Four-stroke engines are common in many off-highway motorcycles and have been used for many years. Certification data from California's off-highway program presented below in Table 4.5-3, as well as data from our own testing (see Table 4.5-1 above) suggest that four-stroke engines with some minor fuel system calibration modifications will be capable of meeting our emission standards even when considering production variability and deterioration. We believe the current sales volumes of two-stroke off-highway motorcycles, combined with the cost to modify two-stroke engines for significant emission reductions, will discourage the use of two-stroke engine technology.

Table 4.5-3
2001 Model Year California Off-highway Motorcycle Certification Data (g/km)

Manufacturer	Model*	Engine Disp.	HC	CO
Honda	XR650R	650 cc	1.0	11.7
Honda	XR400R	400 cc	0.5	6.2
Honda	XR200R	200 cc	0.7	6.8
Honda	XR100R	100 cc	0.8	4.9
Honda	XR80R	80 cc	0.6	6.3
Honda	XR70R	70 cc	0.8	8.2
Honda	XR50R	50 cc	1.0	8.6
Kawasaki	KLX300	300 cc	1.0	5.1
Yamaha	TT-R250	250 cc	0.7	10.9
Yamaha	TT-R225	225 cc	0.7	12.4
Yamaha	TT-R125	125 cc	0.8	5.1
Yamaha	TT-R90	90 cc	0.8	4.9

* All models are four-stroke

4.6 Permeation Control from Recreational Vehicles

The following paragraphs summarize the data and rationale supporting the permeation emission standards for recreational vehicles, which are listed in the Executive Summary.

4.6.1 Baseline Technology and Emissions

4.6.1.1 Fuel Tanks

Recreational vehicle fuel tanks are generally blow-molded or injection-molded using high density polyethylene (HDPE). Data on the permeation rates of fuel through the walls of polyethylene fuel tanks shows that recreational vehicle HDPE fuel tanks have very high permeation rates compared to those used in automotive applications. We tested four ATV fuel tanks in our lab for permeation. We also tested three portable marine fuel tanks and two portable gas cans which are of similar construction. This testing was performed at 29°C (85°F) with gasoline. Prior to testing, the fuel tanks had been stored with fuel in them for more than a month to stabilize the permeation rate. The permeation rates are presented in Table 4.6-1. The average for these ten fuel tanks is 1.32 grams per gallon per day.

Table 4.6-1: Permeation Rates for Plastic Fuel Tanks Tested by EPA at 29°C

Tank Capacity [gallons]	Permeation Loss [g/gal/day]	Tank Type
1.3	1.66	all terrain vehicle
1.3	2.90	all terrain vehicle
1.8	1.29	all terrain vehicle
2.1	2.28	all terrain vehicle
5.3	1.00	all terrain vehicle
6.0	0.61	portable marine
6.0	1.19	portable marine
6.0	0.78	portable marine
6.6	0.77	portable fuel container
6.6	0.75	portable fuel container

The California Air Resources Board (ARB) investigated permeation rates from portable fuel containers and lawn & garden equipment fuel tanks. Although this testing was not on recreational vehicle fuel tanks, the fuel tanks tested are of similar construction. The ARB data is compiled in several data reports on their web site and is included in our docket.[27,28,29,30,31] Table 4.6-2 presents a summary of this data which was collected using the ARB test procedures described in Section 4.6.3. Although the test temperature is cycled from 18 - 41°C rather than held at a constant temperature, the results would likely be similar if the data were collected at the average temperature of 29°C used in the EPA testing. The average for these 36 fuel tanks is 1.07 grams per gallon per day.

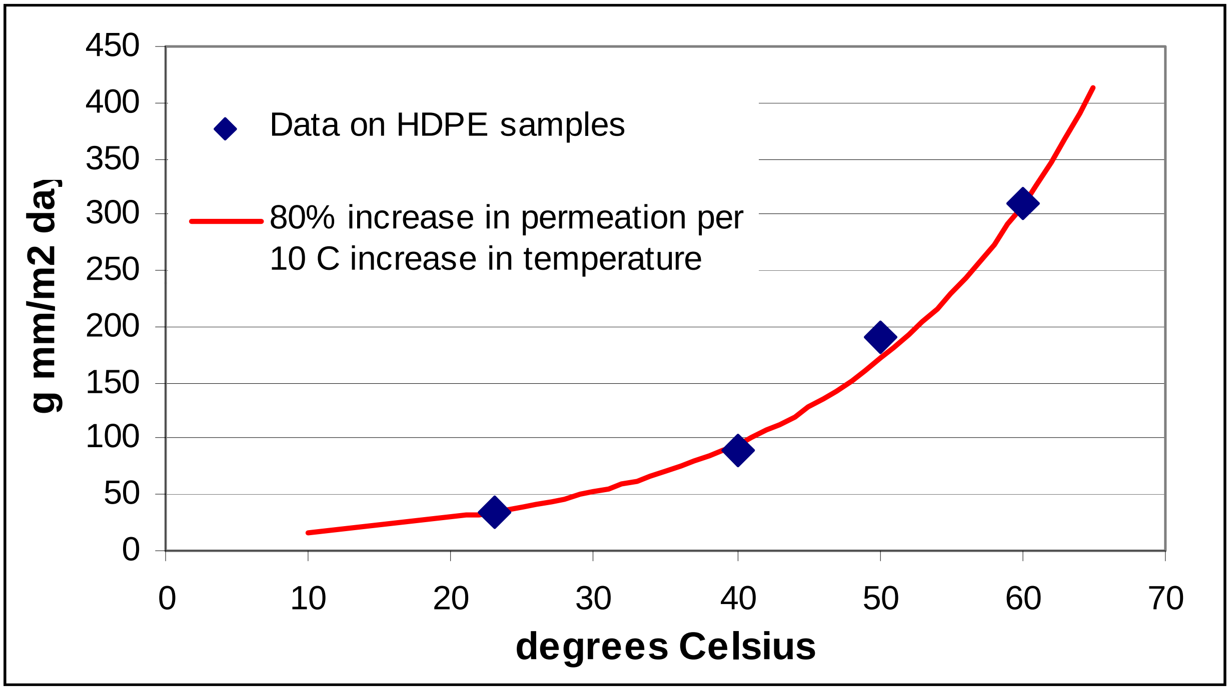
Table 4.6-2: Permeation Rates for Plastic Fuel Containers Tested by ARB Over a 18-41°C Diurnal

Tank Capacity [gallons]	Permeation Loss [g/gal/day]	Tank Type
1.0	1.63	portable fuel container
1.0	1.63	portable fuel container
1.0	1.51	portable fuel container
1.0	0.80	portable fuel container
1.0	0.75	portable fuel container
1.0	0.75	portable fuel container
1.3	0.50	portable fuel container
1.3	0.49	portable fuel container
1.3	0.51	portable fuel container
1.3	0.52	portable fuel container
1.3	0.51	portable fuel container
1.3	0.51	portable fuel container
1.3	1.51	portable fuel container
1.3	1.52	portable fuel container
1.4	1.27	lawn & garden
1.7	0.67	lawn & garden
2.1	1.88	portable fuel container
2.1	1.95	portable fuel container
2.1	1.91	portable fuel container
2.1	1.78	portable fuel container
2.5	1.46	portable fuel container
2.5	1.09	portable fuel container
3.9	0.77	lawn & garden
3.9	0.88	lawn & garden
5.0	0.89	portable fuel container
5.0	0.62	portable fuel container
5.0	0.99	portable fuel container
5.0	0.55	lawn & garden
5.0	0.77	lawn & garden
5.0	0.64	lawn & garden
5.0	1.39	portable fuel container
5.0	1.46	portable fuel container
5.0	1.41	portable fuel container
5.0	1.47	portable fuel container
6.6	1.09	portable fuel container
7.5	0.35	lawn & garden

It is well known that the rate of permeation is a function of temperature. For most materials, permeability increases by about a factor of 2 for every 10°C increase in temperature.[32] Based on data collected on HDPE samples at four temperatures,[33,34] we estimate that the permeation of gasoline through HDPE increases by about 80 percent for every 10°C increase in temperature. This relationship is presented in Figure 4.6-1, and the numeric data can be found in

Section 4.6.2.3.

Figure 4.6-1: Effect of Temperature on HDPE Permeation



Based on the data from 46 fuel tanks in Tables 8.4-1 and 8.4-2, the average permeation rate at 29°C is 1.12 grams per gallon per day. However, the standard is based on units of grams per square meter per day at 28°C. Based on measurements of cut away fuel tanks of this size, we have found that the wall thickness ranges from 4 to 5 mm. Using an average wall thickness of 4.5 mm and a permeation rate for HDPE of 47 g mm/m^2/day at 28°C (Figure 4.6-1) we estimate that the baseline permeation rate is about 10.4 g/m^2/day. Data presented later in this chapter (see Section 4.2.8.3) shows that the permeation rate of fuel through HDPE is fairly insensitive to the amount of alcohol in the fuel.

4.6.1.2 Fuel Hoses

Fuel hoses produced for use in recreational vehicles are generally extruded nitrile rubber with a cover for abrasion resistance. These hoses are generally designed to meet the requirements under SAE J30[35] for an R7 classification. R7 hose has a maximum permeation rate of 550 g/m^2/day at 23°C on ASTM Fuel C (50% toluene, 50% iso-octane). On a fuel containing an alcohol blend, permeation would likely be higher from these fuel hoses. R7 hose is made primarily of nitrile rubber (NBR). Based on the data presented in Section 4.2.8.3, permeation through NBR is about 50 percent higher when tested on Fuel CE10 (10% ethanol) compared to testing on Fuel C.

4.6.2 Permeation Reduction Technologies

4.6.2.1 Fuel Tanks

As discussed in Chapter 3, there are several strategies that can be used to reduce permeation from plastic fuel tanks. This section presents data collected on five permeation control strategies: sulfonation, fluorination, non-continuous barrier platelets, coextruded continuous barrier, and alternative materials.

4.6.2.1.1 Sulfonation

We tested one sulfonated, 6 gallon, HDPE, portable marine fuel tank at 29°C (85°F) with gasoline. Prior to testing, the fuel tank had been stored with gasoline in it for more than 10 weeks to stabilize the permeation rate. We measured a permeation rate of 0.08 g/gallon/day which represents more than a 90 percent reduction from baseline.

The California Air Resources Board (ARB) collected test data on permeation rates from sulfonated portable fuel containers using California certification fuel.[36] The results show that sulfonation can be used to achieve significant reductions in permeation from plastic fuel containers. This data was collected using a diurnal cycle from 18-41°C which is roughly equivalent to steady-state permeation testing at 30°C. The average emission rate for the 32 sulfonated fuel tanks is 0.35 g/gal/day; however, there was a wide range in variation in the effectiveness of the sulfonation process for these fuel tanks. Some of the data outliers were actually higher than baseline emissions. This was likely due to leaks in the fuel tank which would result in large emission increases due to pressure built up with temperature variation over the diurnal cycle. Removing these five outliers, the average permeation rate is 0.17 g/gal/day with a minimum of 0.01 g/gal/day and a maximum of 0.64 g/gal/day.

Variation can occur in the effectiveness of this surface treatment if the sulfonation process is not properly matched to the plastic and additives used in the fuel tank material. For instance, if the sulfonater does not know what UV inhibitors or plasticizers are used, they cannot maximize the effectiveness of their process. In this test program, the sulfonater was not aware of the chemical make up of the fuel tanks. This is the likely reason for the variation in the data even when the obvious outliers are removed. In support of this theory, the permeation rates were consistently low for tanks provided by two of the four tank manufacturers. For these 11 fuel tanks, the average permeation rate was 0.07 which represents more than a 90 percent reduction from baseline. Earlier data collected by ARB showed consistently high emissions from sulfonated fuel tanks; however, ARB and the treatment manufacturers agree that this was due to inexperience with treating fuel tanks and that these issues have since been largely resolved.[37] For this reason we do not include the earlier data in this analysis. Table 4.6-3 includes all of the permeation data, including the outliers.

Table 4.6-3: Permeation Rates for Sulfonated Plastic Fuel Containers Tested by ARB Over a 18-41°C Diurnal

Tank Capacity [gallons]	Permeation Loss [g/gal/day]
1	0.05
1	0.05
1	0.05
1	0.06
1	0.06
1	0.06
1	0.08
1	0.12
1	0.14
1	1.23
1	1.47
1	1.87
2	0.02
2	0.02
2	0.48
2	0.54
2	1.21
2.5	0.03
2.5	0.08
2.5	0.32
2.5	0.38
2.5	0.42
2.5	0.52
2.5	0.64
2.5	0.80
5	0.01
5	0.04
5	0.05
5	0.06
5	0.11
5	0.13
5	0.15

ARB also investigated the effect of fuel slosh on the durability of sulfonated surfaces. Three sulfonated fuel tanks were tested for permeation before and after being rocked with fuel in them 1.2 million times.[38] The results of this testing show that an 85% reduction in permeation was achieved on average even after the slosh testing was performed. Table 4.6-4 presents these results which were recorded in units of g/m^2/day. The baseline level is an approximation based on testing of similar fuel tanks.

As with earlier tests performed by ARB, the sulfonater was not aware of the materials used in the fuel tanks sulfonated for the slosh testing. After the tests were performed, the sulfonater was able to get some information on the chemical make up of the fuel tanks and how it might affect the sulfonation process. For example, the UV inhibitor used in some of the fuel tanks is known as HALS. HALS also has the effect of reducing the effectiveness of the sulfonation process. Two other UV inhibitors, known as carbon black and adsorber UV, are also used in similar fuel tank applications. These UV inhibitors cost about the same as HALS, but have the benefit of not interfering with the sulfonation process. The sulfonater claimed that if HALS were not used in the fuel tanks, a 97% reduction in permeation would have been seen.[39] A list of resins and additives that are compatible with the sulfonation process is included in the docket.[40,41]

Table 4.6-4: Permeation Rates for Sulfonated Fuel Tanks with Slosh Testing by ARB Over a 18-41°C Diurnal

Technology Configuration	Units	Tank 1	Tank 2	Tank 3	Average
Approximate Baseline	$g/m^2/day$	10.4	10.4	10.4	10.4
Sulfonated	$g/m^2/day$ % reduction	0.73 93%	0.82 92%	1.78 83%	1.11 89%
Sulfonated & Sloshed	$g/m^2/day$ % reduction	1.04 90%	1.17 89%	2.49 76%	1.57 85%

An in-use durability testing program was also completed for sulfonated HDPE fuel tanks and bottles.[42] The fuel tank had a 25 gallon capacity and was removed from a station wagon that had been in use in southern California for five years (35,000 miles). The fuel tank was made of HDPE with carbon black used as an additive. After five years, the sulfonation level measured on the surface of the plastic fuel tank did not change. Tests before and after the aging both showed a 92 percent reduction in gasoline permeation due to the sulfonation barrier compared to the permeation rate of a new untreated tank. Testing was also done on 1 gallon bottles made of HDPE with 3% carbon black. These bottles were shown to retain over a 99 percent barrier after five years. This study also looked at other properties such as yield strength and mechanical fatigue and saw no significant deterioration.

One study looked at the effect of alcohol in the fuel on permeation rates from sulfonated fuel tanks.[43] In this study, the fuel tanks were tested with both gasoline and various methanol blends. No significant increase in permeation due to methanol in the fuel was observed.

4.6.2.1.2 Fluorination

We tested one fluorinated, 6 gallon, HDPE, portable marine fuel tank at 29°C (85°F) with gasoline. Prior to testing, the fuel tank had been stored with gasoline in it for about 20 weeks to stabilize the permeation rate. We measured a permeation rate of 0.05 g/gallon/day which represents more than a 95 percent reduction from baseline.

The California Air Resources Board (ARB) collected test data on permeation rates from fluorinated portable fuel containers using California certification fuel.[44,45] The results, presented in Table 4.6-5, show that fluorination can be used to achieve significant reductions in permeation from plastic fuel containers. This data was collected using a diurnal cycle from 18-41°C which is roughly equivalent to steady-state permeation testing at 30°C. Four different levels of fluorination treatment were tested. The average permeation rate for the 87 fluorinated fuel tanks is 0.21 g/gal/day which represents about a 75 percent reduction from baseline. However, for the highest level of fluorination, the average permeation rate was 0.04 g/gal/day which represents a 95 percent reduction from baseline. Earlier data collected by ARB showed consistently high emissions from fluorinated fuel tanks; however, ARB and the treatment manufacturers agree that this was due to inexperience with treating fuel tanks and that these issues have since been largely resolved.[46] For this reason we do not include the earlier data in this analysis.

Table 4.6-5: Permeation Rates for Fluorinated Plastic Fuel Containers Tested by ARB Over a 18-41°C Diurnal

Barrier Treatment*	Tank Capacity [gallons]	Permeation Loss [g/gal/day]
Level 3	1	0.04
	1	0.06
(average = 0.27 g/gal/day)	1	0.25
	2	0.12
	2	0.15
	2	0.17
	2	0.09
	2	0.15
	2	0.12
	2	0.18
	2	0.17
	2	0.14
	2	0.18
	2	0.34
	2	0.41
	2	0.41
	2	0.36
	2	0.41
	2	0.23
	2	0.29
	2	0.31

	2	0.24
	2	0.32
	2	0.16
	2	0.19
	2	0.20
	2	0.11
	2	0.20
	5	0.06
	5	0.06
	5	0.07
	5	0.09
	5	0.10
	5	0.11
	5	0.15
	5	0.23
	5	0.31
	5	0.33
	5	0.24
	5	0.33
	5	0.33
	5	0.51
	5	0.47
	5	0.41
	5	0.45
	5	0.45
	5	0.35
	5	0.37
	5	0.28
	5	0.26
	5	0.35
	5	0.35
	5	0.37
	5	0.28
	5	0.35
	5	0.41
	5	0.47
	5	0.43
	5	0.39
	5	0.47
	5	0.55
Level 4 (average =0.09 g/gal/day)	1 1 1 5 5 5	0.05 0.05 0.06 0.11 0.11 0.15

Level 5 (average =0.07 g/gal/day)	1 1 1 1 1 1 1 1 1 2.5 2.5 2.5 2.5 2.5 5 5 5	0.03 0.04 0.05 0.05 0.07 0.08 0.11 0.11 0.12 0.04 0.04 0.05 0.07 0.07 0.05 0.10 0.11
SPAL (average =0.04 g/gal/day)	5 5 5	0.04 0.04 0.04

*designations used in ARB report; shown in order of increasing treatment

All of the data on fluorinated fuel tanks presented above were based on fuel tanks fluorinated by the same company. Available data from another company that fluorinates fuel tanks shows a 98 percent reduction in gasoline permeation through a HDPE fuel tank due to fluorination.[47]

ARB investigated the effect of fuel slosh on the durability of fluorinated surfaces. Three fluorinated fuel tanks were tested for permeation before and after being rocked with fuel in them 1.2 million times.[48] The results of this testing show that an 80% reduction in permeation was achieved on average even after the slosh testing was performed. However, this data also shows that an 89 percent reduction is feasible. Table 4.6-6 presents these results which were recorded in units of g/m^2/day. The baseline level is an approximation based on testing of similar fuel tanks.

Table 4.6-6: Permeation Rates for Fluorinated Fuel Tanks with Slosh Testing by ARB Over a 18-41°C Diurnal

Technology Configuration	Units	Tank 1	Tank 2	Tank 3	Average
Approximate Baseline	$g/m^2/day$	10.4	10.4	10.4	10.4
Fluorinated	$g/m^2/day$ % reduction	1.17 89%	1.58 85%	0.47 96%	1.07 90%
Fluorinated & Sloshed	$g/m^2/day$ % reduction	2.38 77%	2.86 73%	1.13 89%	2.12 80%

One study looked at the effect of alcohol in the fuel on permeation rates from fluorinated fuel tanks.[49] In this study, the fuel tanks were tested with both gasoline and various methanol blends. No significant increase in permeation due to methanol in the fuel was observed.

4.6.2.1.3 Barrier Platelets

We tested four portable gas cans molded with low permeation non-continuous barrier platelets 29°C (85°F) with gasoline. Prior to testing, the fuel tanks had been stored with gasoline in it for more than 10 weeks to stabilize the permeation rate. Table 4.6-7 presents the emission results which represent an average of nearly an 85 percent reduction from baseline.

Table 4.6-7: Permeation Rates for Plastic Fuel Containers with Barrier Platelets Tested by EPA at 29°C

Percent Selar®*	Tank Capacity [gallons]	Permeation Loss [g/gal/day]
4%	5	0.34
4%	5.3	0.10
4%	6.6	0.14
4%	6.6	0.13

*trade name for barrier platelet technology used in test program

The California Air Resources Board (ARB) collected test data on permeation rates from portable fuel containers molded with low permeation non-continuous barrier platelets using California certification fuel. The results show that this technology can be used to achieve significant reductions in permeation from plastic fuel containers. This data was collected using a diurnal cycle from 18-41°C which is roughly equivalent to steady-state permeation testing at 30°C. Five different percentages of the barrier material were tested. The average permeation rate for the 67 fuel tanks is 0.24 g/gal/day; however, there was a wide range in variation in the effectiveness of the barrier platelets for these fuel tanks. Some of the data outliers were actually higher than baseline emissions. This was likely due to leaks in the fuel tank which would result in large emission increases due to pressure built up with temperature variation over the diurnal cycle. Removing these six outliers, the average permeation rate is 0.15 g/gal/day with a minimum of 0.04 g/gal/day and a maximum of 0.47 g/gal/day. This represents more than an 85 percent reduction from the average baseline. Table 4.6-8 includes all of the ARB test data, including the outliers.

Table 4.6-8: Permeation Rates for Plastic Fuel Containers with Barrier Platelets Tested by ARB Over a 18-41°C Diurnal

Percent Selar®*	Tank Capacity [gallons]	Permeation Loss [g/gal/day]
4%	5.00	0.08
	5.00	0.09
(average =0.12 g/gal/day)	5.00	0.13
	5.00	0.16
	5.00	0.17
	6.00	0.08
	6.00	0.10
6%	2.00	0.06
	2.00	0.07
(average =0.16 g/gal/day)	2.00	0.10
	2.00	0.10
	2.00	0.11
	2.00	0.11
	2.00	0.28
	2.00	0.44
	2.00	0.45
	2.00	0.47
	5.00	0.07
	5.00	0.07
	5.00	0.07
	5.00	0.08
	5.00	0.12
	5.00	0.17
	6.00	0.06
	6.00	0.07

8%	1.00	0.14
	1.00	0.17
(average =0.32 g/gal/day)	1.00	0.21
	1.00	0.21
	1.00	0.21
	1.00	0.65
	1.00	0.85
	1.00	0.98
	1.00	1.66
	2.00	0.04
	2.00	0.05
	2.00	0.07
	2.00	0.09
	2.00	0.12
	2.00	0.16
	2.00	0.44
	5.00	0.08
	5.00	0.10
	6.00	0.05
	6.00	0.06
10%	1.00	0.15
	1.00	0.19
(average =0.28 g/gal/day)	1.00	0.19
	1.00	0.21
	1.00	0.23
	1.00	0.26
	1.00	0.79
	1.00	0.83
	1.00	0.88
	2.00	0.06
	2.00	0.06
	2.00	0.07
	2.00	0.08
	2.00	0.13
	2.00	0.14
	2.00	0.23
12%	1.00	0.13
	1.00	0.14
(average =0.21 g/gal/day)	1.00	0.20
	1.00	0.21
	1.00	0.23
	1.00	0.35

*trade name for barrier platelet technology used in test program

The fuel containers tested by ARB used a technology known as Selar® which uses nylon as the barrier resin. Dupont, who manufacturers Selar®, has recently developed a new resin

(Selar RB®) that uses ethylene vinyl alcohol (EVOH) as the barrier resin. EVOH has much lower permeation than nylon, especially with alcohol fuel blends (see Section 4.6.2.3). Table 4.6-9 presents permeation rates for HDPE and three Selar RB® blends when tested at 60°C on xylene.[50] Xylene is a component of gasoline and gives a rough indication of the permeation rates on gasoline. This report also shows a reduction of 99% on naptha and 98% on toluene for 8% Selar RB®.

Table 4.6-9: Xylene Permeation Results for Selar RB® at 60°C

Composition	Permeation, g mm/m^2/day	% Reduction
100% HDPE	285	–
10% RB 215/HDPE	0.4	99.9%
10% RB 300/HDPE	3.5	98.8%
15% RB 421/HDPE	0.8	99.7%

4.6.2.1.4 Coextruded barrier

One study looks at the permeation rates, using ARB test procedures, through multi-layer fuel tanks.[51] The fuel tanks in this study were 6 layer coextruded plastic tanks with EVOH as the barrier layer (3% of wall thickness). The outer layers were HDPE and two adhesive layers were needed to bond the EVOH to the polyethylene. The sixth layer was made of recycled polyethylene. The two test fuels were a 10 percent ethanol blend (CE10) and a 15 percent methanol blend (CM15). See Table 4.6-10.

Table 4.6-10: Permeation Results for a Coextruded Fuel Tank Over a 18-41°C Diurnal

Composition	Permeation, g/day	% Reduction
100% HDPE (approximate)	6 - 8	–
3% EVOH, 10% ethanol (CE10)	0.2	97%
3% EVOH, 15% methanol (CM15)	0.3	96%

4.6.2.1.5 Alternative Materials

Permeation can also be reduced from fuel tanks by constructing them out of a lower permeation material than HDPE. For instance, an that would reduce permeation is the use of metal fuel tanks because gasoline does not permeate through metal. In addition, there are grades of plastics other than HDPE that could be molded into fuel tanks. One material that has been considered by manufacturers is nylon; however, although nylon has excellent permeation resistance on gasoline, it has poor chemical resistance to alcohol-blended fuels. As shown in Table 4.6-14, nylon would result in about a 98 percent reduction in permeation compared to HDPE for gasoline. However, for a 10 percent ethanol blend, this reduction would only be about 40-60 percent depending on the grade of nylon. For a 15 percent methanol blend, the permeation would actually be several times higher through nylon than HDPE.

Other materials, which have excellent permeation even with alcohol-blended fuels are acetal copolymers and thermoplastic polyesters. These polymers can be used to form fuel tanks in the blow-molding, rotational-molding, and injection-molding processes. An example of an acetal copolymer is known as Celcon® which has excellent chemical resistance to fuel and has been shown to be durable based on exposure to automotive fuels for 5000 hours at high temperatures.[52] As shown in Table 4.6-14, Celcon® would result in more than a 99 percent reduction in permeation compared to HDPE for gasoline. On a 10 percent ethanol blend, the use of Celcon® would result in more than a 95 percent reduction in permeation. Two thermoplastic polyesters, known as Celanex® and Vandar®, are being considered for fuel tank construction and are being evaluated for permeation resistance by the manufacturer.

4.6.2.2 Fuel Hoses

Thermoplastic fuel lines for automotive applications are generally built to SAE J2260 specifications.[53] Category 1 fuel lines under this specification have permeation rates of less than 25 g/m^2/day at 60°C on CM15 fuel. One thermoplastic used in automotive fuel line construction is polyvinylidene fluoride (PVDF). Based on the data presented in Section 4.6.2.3, a PDVF fuel line with a typical wall thickness (1 mm) would have a permeation rate of 0.2 g/m^2/day at 23°C on CM15 fuel. However, recreational vehicle manufacturers have commented that this fuel line would not be flexible enough to use in their applications because they require flexible rubber hose to fit tight radii and to resist vibration. In addition, using plastic fuel line rather than rubber hose would require the additional cost of changing hose fittings on the vehicles.

Manufacturers recommended using R9 fuel hose as a low permeation requirement. This hose is designated under SAE recommended practice J30[54] for fuel injection systems and has a maximum permeation rate of 15 g/m^2/day on ASTM Fuel C. On a fuel containing an alcohol blend, permeation would likely be much higher from these fuel hoses. SAE J30 specifically notes that “exposure of this hose to gasoline or diesel fuel which contain high levels, greater than 5% by volume, of oxygenates, i.e., ethanol, methanol, or MTBE, may result in significantly higher permeation rates than realized with ASTM Fuel C.” R9 hose is made with a thin low permeation barrier sandwiched between layers of rubber. A typical barrier material used in this construction is FKM. Based on the data presented in Section 4.2.8.3 for FKM, the permeation rate is 3-5 times higher on Fuel CE10 than Fuel C. Therefore, a typical R9 hose meeting 15 g/m^2/day at 23°C on Fuel C may actually permeate at a level of 40-50 g/m^2/day on fuel with a 10 percent ethanol blend.

SAE J30 also designates R11 and R12 hose which are intended for use as low permeation fuel feed and return hose. R11 has thee classes known as A, B, and C. Of these, R11-A has the lowest permeation specification which is a maximum of 25 g/m^2/day at 40°C on CM15 fuel. Because permeation rates are generally higher on CM15 than CE10 and because they are 2-4 times higher at 40°C than at 23°C, hose designed for this specification would likely meet our permeation requirement. R12 hose has a permeation requirement of 100 g/m^2/day at 60°C on CM15 fuel. This is roughly equivalent in stringency as the R11-A permeation requirement.

There are lower permeation fuel hoses available today that are manufactured for automotive applications. These hoses are generally used either as vapor hoses or as short sections of fuel line to provide flexibility and absorb vibration. One example of such a hose[55] is labeled by General Motors as "construction 6" which is a multilayer hose with an inner layer of THV sandwiched in inner and outer layers of a rubber known as ECO.[cc] A hose of this construction would have less than 8 g/m^2/day at 40°C when tested on CE10. In look and flexibility, this hose is not significantly different than the SAE J30 R7 hose generally used in recreational vehicle applications.

Permeation data on several low permeation hose designs were provided to EPA by an automotive fuel hose manufacturer.[56] This hose, which is as flexible as R9 hose, was designed for automotive applications and is available today. Table 4.6-11 presents permeation data on three hose designs that use THV 800 as the barrier layer. The difference in the three designs is the material used on the inner layer of the hose. This material does not significantly affect permeation emissions through the hose but can affect leakage at the plug during testing (or connector in use) and fuel that passes out of the end of the hose which is known as wicking. The permeation testing was performed using the ARB 18-41°C diurnal cycle using a fuel with a 10 percent ethanol blend (E10).

Table 4.6-11: Hose Permeation Rates with THV 800 Barrier over ARB Cycle (g/m^2/day)

Hose Name	Inner Layer	Permeation	Wicking	Leaking	Total
CADBAR 9610	THV	0.16	0.00	0.02	0.18
CADBAR 9710	NBR	0.17	0.29	0.01	0.47
CADBAR 9510	FKM	0.16	0.01	0.00	0.18

The data presented above shows that there is hose available that can easily meet the hose permeation standard on E10 fuel. Although hose using THV 800 is available, it is produced for automobiles that will need to meet the tighter evaporative emission requirements in the upcoming Tier 2 standards. Hose produced in mass quantities today uses THV 500. This hose is less expensive and could be used to meet the recreational vehicle permeation requirements. Table 4.6-12 presents information comparing hose using THV 500 with the hose described above using THV 800 as a barrier layer.[57] In addition, this data shows that permeation rates more than double when tested on CE10 versus Fuel C. One recreational vehicle manufacturer has expressed concern to EPA that this hose may be too stiff to stay on the fuel line and fuel tank connectors without clamps as does their current fuel line. If a manufacturer opts to use this or a

[cc] THV = tetrafluoroethylene hexafluoropropylene, ECO = epichlorohydrin/ethylene oxide

similar line, this problem will need to be resolved either through further testing, a change to the connector geometry, the use of an adhesive, or the use of one of any of several of different types of clamps.

Table 4.6-12: Comparison of Hose Permeation Rates with THV 500 and 800 ($g/m^2/day$)*

Hose Inner Diameter, mm	THV 500		THV 800	
	Fuel C	Fuel CE10	Fuel C	Fuel CE10
6	0.5	1.4	0.2	0.5
8	0.5	1.4	0.3	0.5
10	0.5	1.5	0.2	0.5

* Calculated using data from Thwing Albert materials testing (may overstate permeation)

We contracted with an independent testing laboratory to test a section of R9 hose and a section of automotive vent line hose for permeation.[58] These hoses had a six mm inner diameter. The test lab used the SAE J30 test procedures for R9 hose with both Fuel C and Fuel CE10. We purchased the R9 hose (which was labeled as such) from a local auto parts store. According to this testing, the R9 hose is well below the SAE specification of 15 $g/m^2/day$. In fact, it meets this limit on Fuel CE10 as well. The automotive vent line showed similar results. This data is presented in Table 4.6-13.

Table 4.6-13: Test Results on Commercially Available Hose Samples ($g/m^2/day$)

Hose Sample	Fuel C	Fuel CE10
R9	10.1	12.1
Automotive vent line	10.9	9.0

4.6.2.3 Material Properties

This section presents data on permeation rates for a wide range of materials that can be used in fuel tanks and hoses. The data also includes effects of temperature and fuel type on permeation. Because the data was collected from several sources, there is not complete data on each of the materials tested in terms of temperature and test fuel. Table 4.6-14 gives an overview of the fuel systems materials included in the data set. Tables 4.6-15 through 4.6-18 present permeation rates using Fuel C, a 10% ethanol blend (CE10), and a 15% methanol blend (CE15) for the test temperatures of 23, 40, 50, and 60°C.

Table 4.6-14: Fuel System Materials

Material Name	Composition
HDPE	high-density polyethylene
Nylon 12	thermoplastic
EVOH	ethylene vinyl alcohol, thermoplastic
Polyacetal	thermoplastic
PBT	polybutylene terephthalate, thermoplastic
PVDF	polyvinylidene fluoride, fluorothermoplastic
NBR	nitrile rubber
HNBR	hydrogenated nitrile rubber
FVMQ	flourosilicone
FKM	fluoroelastomer
FEB	fluorothermoplastic
PFA	fluorothermoplastic
Carilon	aliphatic poly-ketone thermoplastic
HDPE	high density polyethylene
LDPE	low density polyethylene
Celcon	acetal copolymer
THV	tetra-fluoro-ethylene, hexa-fluoro-propylene, vinyledene fluoride
E14659	fluoropolymer film
E14944	fluoropolymer film
ETFE	ethylene-tetrafluoro-ethylene, fluoroplastic
GFLT	fluoroelastomer
FEP	fluorothermoplastic
PTFE	polytetrafluoroethylene, fluoroplastic
FPA	copolymer of tetrafluoroethylene and perfluoroalkoxy monomer

Table 4.6-15: Fuel System Material Permeation Rates at 23°C by Fuel Type [59,60,61,62,63]

Material Name	Fuel C g-mm/m^2/day	Fuel CE10 g-mm/m^2/day	CM15 g-mm/m^2/day
HDPE	35	–	35
Nylon 12, rigid	0.2	–	64
EVOH	–	–	10
Polyacetal	–	–	3.1
PBT	–	–	0.4
PVDF	–	–	0.2
NBR (33% ACN)	669	1028	1188
HNBR (44%ACN)	230	553	828
FVMQ	455	584	635
FKM Viton A200 (66%F)	0.80	7.5	36
FKM Viton B70 (66%F)	0.80	6.7	32
FKM Viton GLT (65%F)	2.60	14	60
FKM Viton B200 (68%F)	0.70	4.1	12
FKM Viton GF (70%F)	0.70	1.1	3.0
FKM Viton GFLT (67%F)	1.80	6.5	14
FKM - 2120	8	–	44
FKM - 5830	1.1	–	8
Teflon FEB 1000L	0.03	0.03	0.03
Teflon PFA 1000LP	0.18	0.03	0.13
Tefzel ETFE 1000LZ	0.03	0.05	0.20
Nylon 12 (GM grade)	6.0	24	83
Nitrile	130	635	1150
FKM	–	16	–
FE 5620Q (65.9% fluorine)	–	7	–
FE 5840Q (70.2% fluorine)	–	4	–
PTFE	0.05	–	0.08*
ETFE	0.02	–	0.04*
PFA	0.01	–	0.05*
THV 500	0.03	–	0.3

* tested on CM20.

Table 4.6-16: Fuel System Material Permeation Rates at 40°C by Fuel Type [64,65]

Material Name	Fuel C g-mm/m^2/day	Fuel CE10 g-mm/m^2/day	CM15 g-mm/m^2/day
Carilon	0.06	1.5	13
EVOH - F101	<0.0001	0.013	3.5
EVOH - XEP380	<0.0001	–	5.3
HDPE	90	69	71
LDPE	420	350	330
Nylon 12 (L2101F)	2.0	28	250
Nylon 12 (L2140)	1.8	44	–
Celcon	0.38	2.7	–
Dyneon E14659	0.25	–	2.1
Dyneon E14944	0.14	–	1.7
ETFE Aflon COP	0.24	0.67	1.8
m-ETFE	0.27	–	1.6
ETFE Aflon LM730 AP	0.41	0.79	2.6
FKM-70 16286	11	35	–
GFLT 19797	13	38	–
Nitrile	–	1540	3500
FKM	–	86	120
FE 5620Q (65.9% fluorine)	–	40	180
FE 5840Q (70.2% fluorine)	–	12	45
THV-310 X	–	–	5.0
THV-500	0.31	–	3.0
THV-610 X	–	–	2.1

Table 4.6-17: Fuel System Material Permeation Rates at 50°C by Fuel Type [66]

Material Name	Fuel C g-mm/m^2/day	Fuel CE10 g-mm/m^2/day	CM15 g-mm/m^2/day
Carilon	0.2	3.6	–
HDPE	190	150	–
Nylon 12 (L2140)	4.9	83	–
Celcon	0.76	5.8	–
ETFE Afcon COP	–	1.7	–
FKM-70 16286	25	79	–
GFLT 19797	28	77	–

Table 4.6-18: Fuel System Material Permeation Rates at 60°C by Fuel Type [67,68,69,70]

Material Name	Fuel C g-mm/m^2/day	Fuel CE10 g-mm/m^2/day	CM15 g-mm/m^2/day
Carilon	0.55	7.5	–
HDPE	310	230	–
Nylon 12 (L2140)	9.5	140	–
Celcon	1.7	11	–
ETFE Afcon COP	–	3.8	–
FKM-70 16286	56	170	–
GFLT 19797	60	130	–
polyeurethane (bladder)	285	460	–
THV-200	–	54	–
THV-310 X	–	–	38
THV-510 ESD	6.1	18	35
THV-500	–	11	20
THV-500 G	4.1	10	22
THV-610 X	2.4	5.4	9.0
ETFE 6235 G	1.1	3.0	6.5
THV-800	1.0	2.9	6.0
FEP	0.2	0.4	1.1

4.6.3 Test Procedures

4.6.3.1 Fuel Tanks

Essentially, two options may be used to test fuel tanks for certification. The first option is to perform all of the durability tests on a fuel tank and then test the permeation rate. The second option is to test a fuel tank that has been preconditioned and adjust the results using a deterioration factor. The deterioration factor would need to be based on testing of that tank or a similar tank unless you can use good engineering judgment to apply the results of previous durability testing with a different fuel system. Figure 4.6-2 provides flow charts for these two options.

4.6.3.1.1 Option 1: full test procedure

Under the first option, the fuel tank is tested both before and after a series of durability tests. We estimate that this test procedure would take about 49 weeks to complete. Prior to the first test, the fuel tank must be preconditioned to ensure that the hydrocarbon permeation rate has stabilized. Under this step, the fuel tank must be filled with a 10 percent ethanol blend (E10), sealed, and soaked for 20 weeks at a temperature of 28 °C ± 5 °C. Once the permeation rate has stabilized, the fuel tank is drained and refilled with E10, sealed, and tested for a baseline permeation rate. The baseline permeation rate from the fuel tank is determined by measuring the weight difference the fuel tank before and after soaking at a temperature of 28 °C ± 2 °C over a period of at least 2 weeks.

To determine a permeation emission deterioration factor, we are specifying three durability tests: slosh testing, pressure-vacuum cycling, and ultra-violet (UV) light exposure. The purpose of these deterioration tests is to help ensure that the technology is durable and the measured emissions are representative of in-use permeation rates. For slosh testing, the fuel tank is filled to 40 percent capacity with E10 fuel and rocked for 1 million cycles. The pressure-vacuum testing contains 10,000 cycles from -0.5 to 2.0 psi. The slosh testing is designed to assess treatment durability as discussed above. These tests are designed to assess surface microcracking concerns. These two durability tests are based on a draft recommended SAE practice.[71] The third durability test is intended to assess potential impacts of UV sunlight (0.2 µm - 0.4 µm) on the durability of the surface treatment. In this test, the tank must be exposed to a UV light of at least 0.40 W-hr/m^2 /min on the tank surface for 15 hours per day for 30 days. Alternatively, it can be exposed to direct natural sunlight for an equivalent period of time in exposure hours.

The order of the durability tests is optional. However, we require that the fuel tank be soaked to ensure that the permeation rate is stabilized just prior to the final permeation test. If the slosh test is run last, the length of the slosh test may be considered as part of this soak period. Where possible, the deterioration tests may be run concurrently. For example, the fuel tank could be exposed to UV light during the slosh test. In addition, if a durability test can clearly be shown to not be appropriate for a given product, manufacturers may petition to have this test waived. For example, a fuel tank that is only used in vehicles where an outer shell prevents the tank from being exposed to sunlight may not benefit from UV testing.

After the durability testing, once the permeation rate has stabilized, the fuel tank is drained and refilled with E10, sealed, and tested for a final permeation rate. The final permeation rate from the fuel tank is determined using the same measurement method as for the baseline permeation rate. The final permeation rate would be used for the emission rate from this fuel tank. The difference between the baseline and final permeation rates would be used to determine a deterioration factor for use on subsequent testing of similar fuel tanks.

4.6.3.1.2 Option 2: base test with DF

Under the second option, the fuel tank is tested for baseline permeation only, then a deterioration factor (DF) is applied. We estimate that this test procedure would take about 22 weeks to complete. As with Option 1 baseline testing, the fuel tank must be preconditioned to ensure that the hydrocarbon permeation rate has stabilized. Under this step, the fuel tank must be filled with a 10 percent ethanol blend (E10), sealed, and soaked for 20 weeks at a temperature of 28 °C ± 5 °C. Once the permeation rate has stabilized, the fuel tank is drained and refilled with E10, sealed, and tested for a baseline permeation rate. The baseline permeation rate from the fuel tank is determined by measuring the weight difference the fuel tank before and after soaking at a temperature of 28 °C ± 2 °C over a period of at least 2 weeks.

The final permeation rate is then determined by applying a DF to the baseline permeation rate. The DF, in units of g/m^2/day, is added to the baseline permeation rate. This DF must be determined with testing on a fuel tank in the same emission family.

4.6.3.2 Fuel Hoses

The permeation rate from fuel hoses would be measured at a temperature of 23 °C ± 2 °C over a period of at least 2 weeks. A longer period may be necessary for an accurate measurement for hose with low permeation rates. Permeation would be measured through the weight loss technique described in SAE J30.[72] The hose must be preconditioned with a fuel soak to ensure that the permeation rate has stabilized. Based on times to achieve equilibrium for permeation measurement described in SAE J2260[73] for automotive fuel lines, and adjusting for temperature and test fuel type, we estimate a minimum soak time of 4 weeks. The fuel used for this testing would be a blend of 90 percent gasoline and ten percent ethanol. This fuel is consistent with the test fuel used for on-highway evaporative emission testing.

4.6.4 Conclusion

We believe that manufacturers will be able to meet the fuel tank permeation requirements through several design strategies that include sulfonation, fluorination, barrier platelets, and coextruded barriers. Our cost analysis, presented in Chapter 5, indicates that sulfonation would likely be the most attractive technology. However, conversations with manufacturers have revealed interest in each of these low permeation strategies. We believe the data presented above supports a final standard which requires about an 85% reduction in permeation, compared baseline HDPE fuel tanks, throughout the useful life of the recreational vehicle.

As discussed above, fuel hose is available today that meets the permeation requirements for recreational vehicles. Low permeation hose was generally developed for automotive applications; however, we believe that this fuel hose can be used in recreational vehicle applications. Even assuming that new hose clamps would be required, our analyses in Chapters 5 and 6 show that the low permeation hose would be inexpensive yet effective.

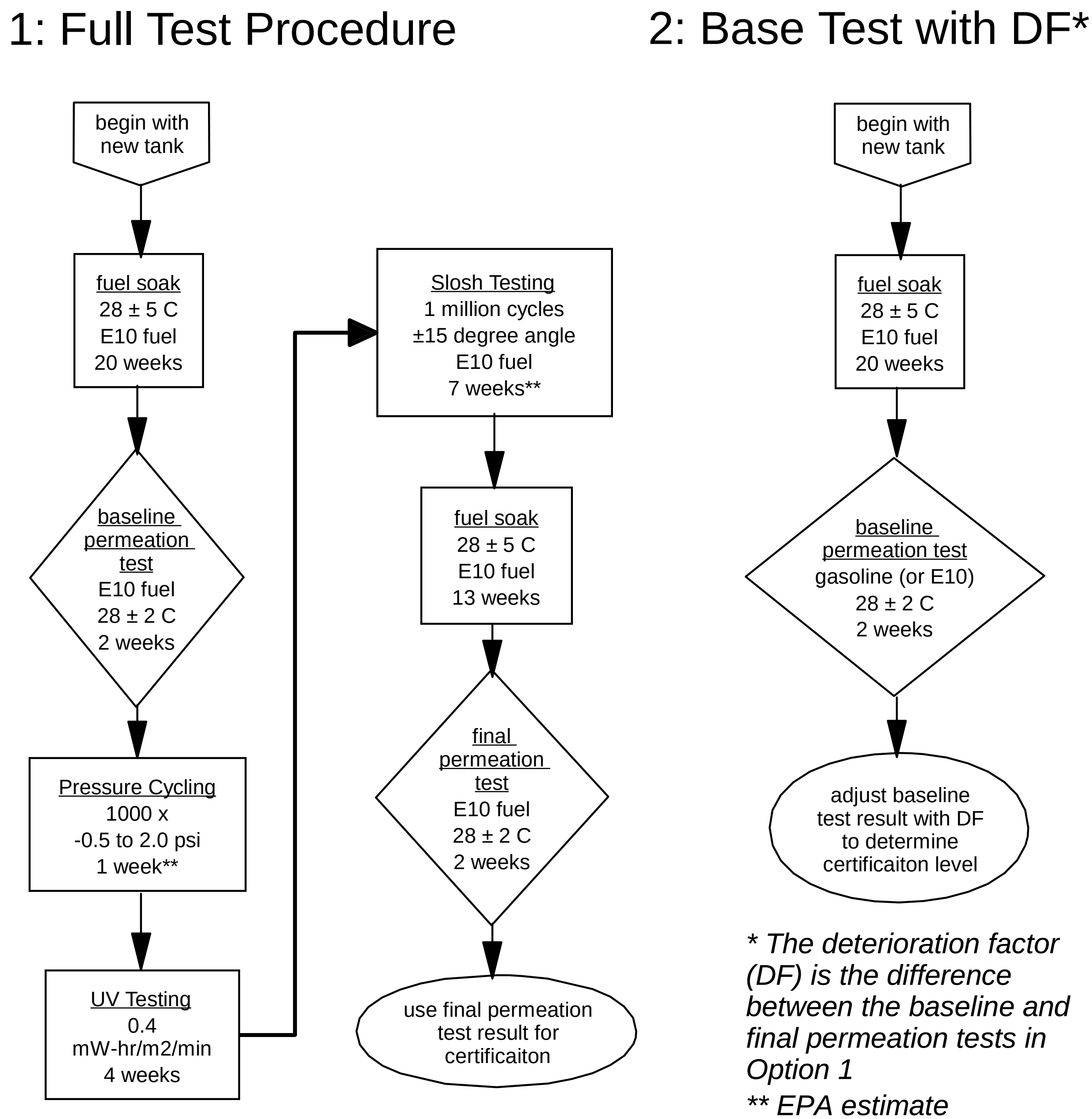
4.6.5 Impacts on Noise, Energy, and Safety

The Clean Air Act requires EPA to consider potential impacts on noise, energy, and safety when establishing the feasibility of new permeation standards for recreational vehicles. In this case, we would not expect evaporative emission controls to have any impact on noise from a vehicle because noise from the fuel system is insignificant.

We anticipate that permeation emission standards will have a positive impact on energy. By capturing or preventing the loss of fuel through permeation, we estimate that the average lifetime fuel savings will be 11.8 gallons for snowmobiles, 5.4 gallons for off-highway motorcycles and 6.5 gallons for all-terrain vehicles. This translates to a fuel savings of about 12 million gallons in 2030 when most recreational vehicles used in the U.S. are expected to have permeation emission control.

We believe that permeation emission standards will have no negative impacts on safety, and may even have some benefits due to the reduction of fuel vapor around a recreational vehicle.

Figure 4.6-2: Flow Chart of Fuel Tank Permeation Certification Test Options



Appendix to Chapter 4: Emission Index For Recreational Vehicle Hangtags

Section1051.135(g) specifies that recreational vehicles should have consumer labels that show the emission characteristics of the vehicle using a normalized zero to ten index. The index is called a nonroad emission rating (NER). This appendix describes the derivation of those indices. The primary indices were derived based on four general principles:

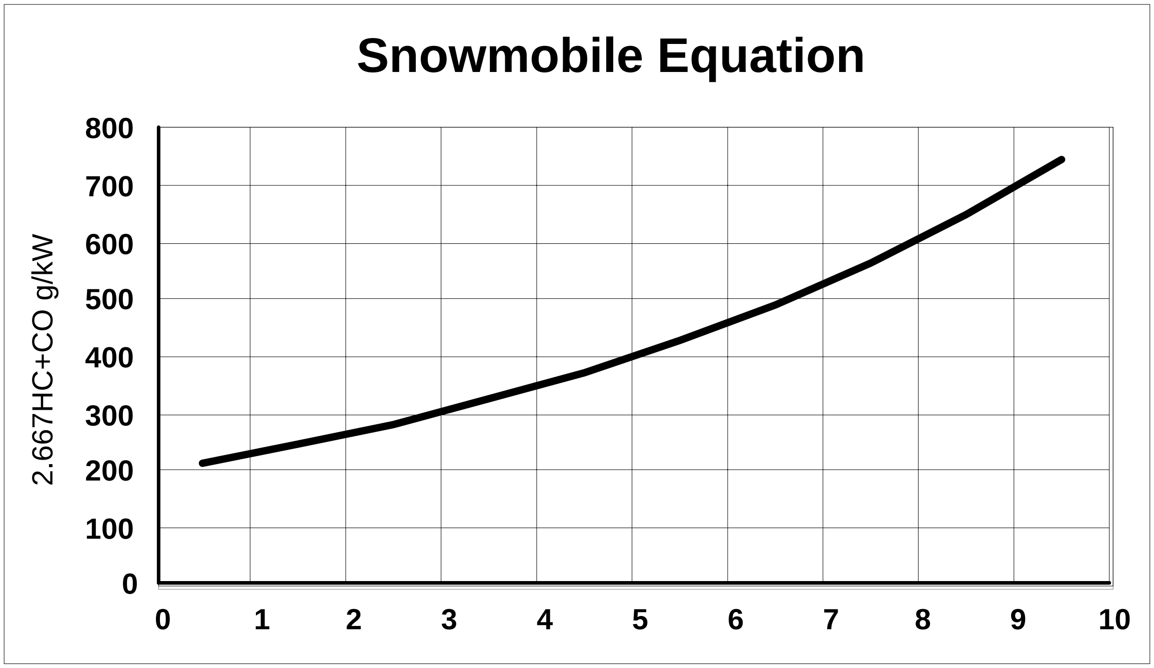
> The index should be simple for the consumer to use.
>
> A vehicle with the highest emissions allowed or expected under the regulations should have a value of ten.
>
> A vehicle with emissions equal to the average standard should be in the middle of the range. (For categories with two phases, a vehicle with emissions equal to the average Phase 2 standard under should be approximately five.)
>
> Each index should allow for vehicles that are significantly cleaner than the average. The indices should also work without adjustment if we were to establish more stringent standards in the future.

As described below, we applied these principles separately to each of the categories, considering the baseline emissions, FEL caps, average standards, and current and future technology options. In general, since the recreational vehicle programs are designed to allow different technology options, we believe that a logarithmic scale in generally appropriate. However, in some cases, a linear scale is more appropriate for all or part of the index. In some cases, it may be possible to have emissions high enough to calculate the NER as eleven or higher. In those cases, the regulations specify that the vehicle should be labeled as a ten.

4A.1 Snowmobiles

The index for snowmobiles uses a single log-linear curve to convert HC and CO emissions into normalized values between zero and ten. HC and CO emissions are weighted based on baseline values so that a 50 percent reduction in HC emissions is equivalent to a 50 percent reduction in CO emissions. (The ratio of baseline CO emissions to baseline HC emissions is 400:150, or 2.667.) The following equation gives a value of ten for vehicles with HC emissions of 150 g/kW-hr and CO emissions 400 g/kW-hr; and a value of five for vehicles with HC emissions of 75 g/kW-hr and CO emissions 200 g/kW-hr:

$$NER = 16.61 \times \log(2.667\,HC + CO) - 38.22$$



4A.2 Off-highway Motorcycles

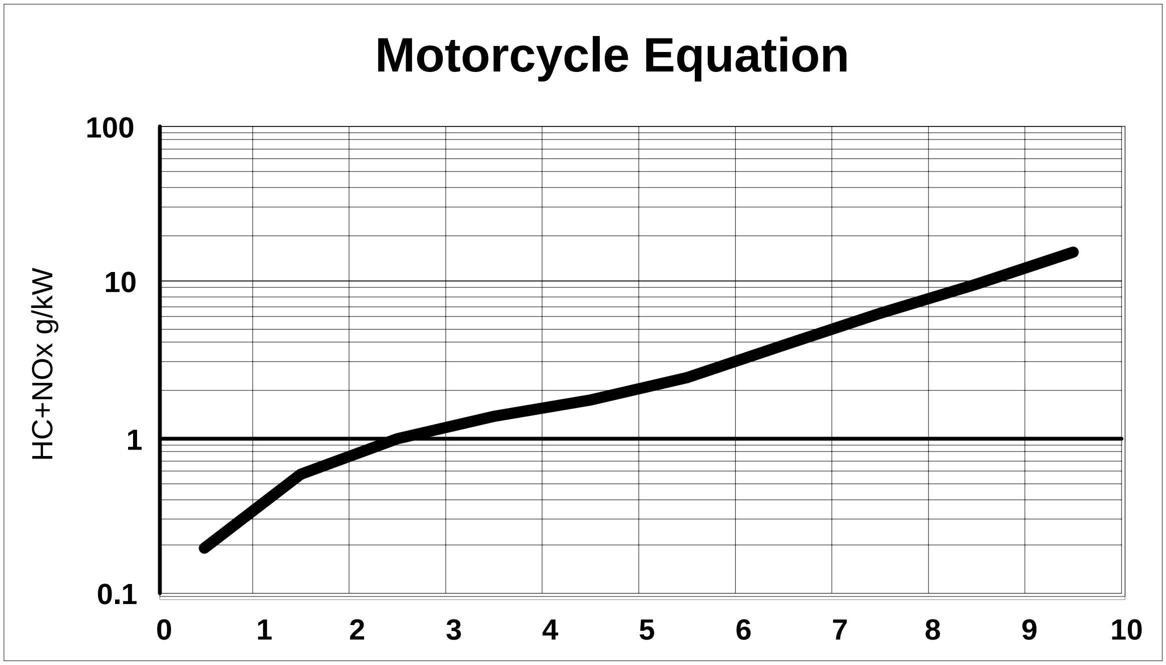
The index for off-highway motorcycles uses a combination of a linear curve and a log-linear curve to convert HC+NOx emissions into normalized values between zero and ten. The following linear equation, which applies for vehicles with below average emissions gives a value of five for vehicles with HC+NOx emissions of 2.0 g/km:

$$NER = 2.500(HC + NOx)$$

The following log-linear equation, which applies for vehicles with above average emissions gives a value of ten for vehicles with HC+NOx emissions of 20 g/km; and a value of five for vehicles with HC+NOx emissions of 2.0 g/km:

$$NER = 5.000 \times \log(HC + NOx) + 3.495$$

It was necessary to use a linear equation for the lower part of the curve to allow for more gradations just below the average, and fewer for very low levels. For example, using the log equation, it would have been necessary to have emission below 1.0 g/km to get an emission rating that would round to three, while with the linear equation, it would only be necessary to have emissions below 1.4 g/km to get an emission rating that would round to three.



4A.3 ATVs (g/km)

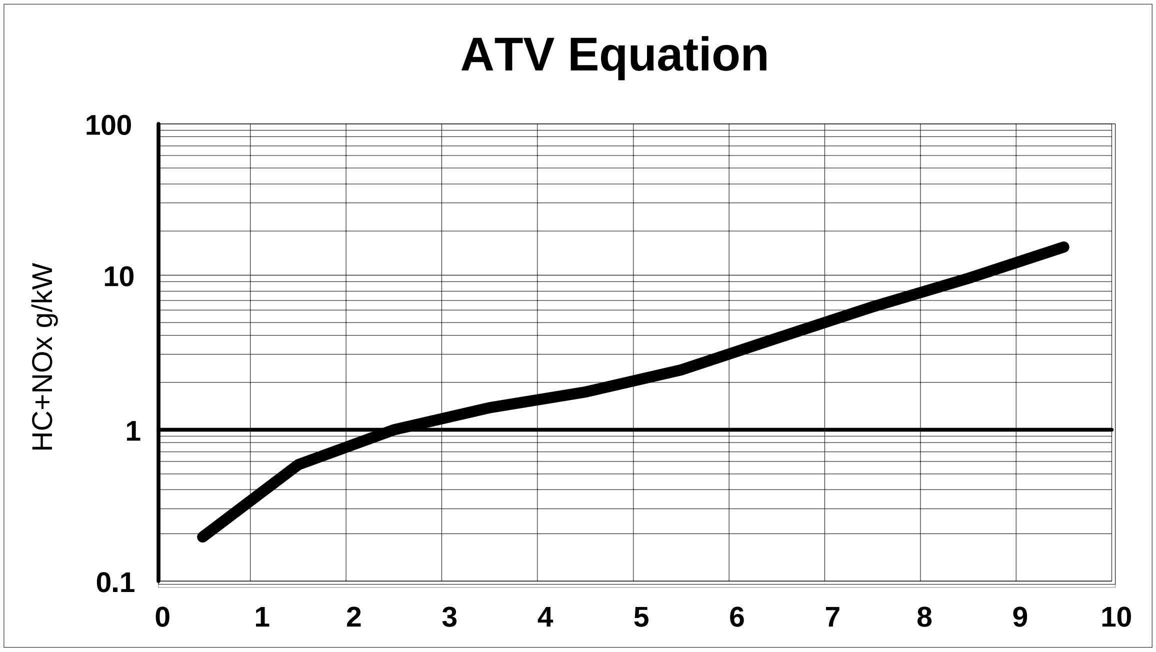
The primary index for ATVs uses a combination of a linear curve and a log-linear curve to convert HC+NOx emissions into normalized values between zero and ten. The following linear equation, which applies for vehicles with below average emissions gives a value of five for vehicles with HC+NOx emissions of 1.5 g/km:

$$NER = 3.333(HC + NOx)$$

The following log-linear equation, which applies for vehicles with above average emissions gives a value of ten for vehicles with HC+NOx emissions of 20 g/km; and a value of five for vehicles with HC+NOx emissions of 1.5 g/km:

$$NER = 4.444 \times \log(HC + NOx) + 4.217$$

It was necessary to use a linear equation for the lower part of the curve to allow for more gradations just below the average, and fewer for very low levels. For example, using the log equation, it would have been necessary to have emission below 0.7 g/km to get an emission rating that would round to three, while with the linear equation, it would only be necessary to have emissions below 1.1 g/km to get an emission rating that would round to three.
where HC +NOx is the cycle-weighted emission rates for hydrocarbons plus oxides of nitrogen in g/km.



4A.4 ATVs (g/kW)

There are two cases in which we allow ATVs to certify to g/kW emission standards based on engine testing: ATVs less than 100 cc, and ATVs built before 2009. We developed separate equations for these cases, based on the same general principles as for other ATVs. In developing these equations, we considered FEL caps, average standards, test cycle issues, and the available technology options. The following linear equation, applies for ATV with engine smaller than 100cc:

$$NER = 0.250(HC + NOx) + 0.250$$

The following log-linear equation, applies for larger ATVs certified under the interim engine testing option:

$$NER = 9.898 \times \log(HC + NOx) - 4.898$$

Chapter 4 References

1. "Emission Testing of Nonroad Compression Ignition Engines," prepared by Southwest Research Institute for the U.S. EPA, SwRI 6886-802, September 1995, Docket A-2000-01, Document II-A-20.

2. Memorandum from Mike Brand, Cummins, to Bill Charmley, U.S. EPA, "Draft Report on *Emission Testing of Nonroad Compression Ignition Engines*," November 13, 1995, Docket A-2000-01, Document II-A-22.

3. Letter from Jeff Carmody, Santa Barbara County Air Pollution Control District, to Mike Samulski, U.S. EPA, "Marine Engine Replacement Programs," July 21, 1997, Docket A-2000-01, Document II-A-21.

4. Facsimile from Eric Peterson, Santa Barbara County Air Pollution Control District, to Mike Samulski, U.S. EPA, "Data on Mercury 4.2 and 2.8 Liter Engines," April 1, 1998, Docket A-2000-01, Document II-A-24.

5. Smith, M., "Marine Diesel Engine Testing," Prepared by Southwest Research Institute for the U.S. EPA, Contract # 68-C-98-169, WA 0-7, September 1999, Docket A-2000-01, Document II-A-26.

6. Data Submission by the Engine Manufacturers Association, July 19, 2000, Docket A-2000-01, Document II-B-11.

7. International Organization for Standardization, 8178-4, "Reciprocating internal combustion engines—Exhaust emission measurement—Part 4: Test cycles for different engine applications," Docket A-2000-01, Document II-A-19.

8. "Control of Emissions of Air Pollution from New Marine Compression-Ignition Engines at or Above 37 kW; Final Rule," 64 FR 73300, December 29, 1999.

9. Wilbur, C., "Marine Diesel Engines," Butterworth & Heinemann Ltd, 1984.

10. "Data Collection and Analysis of Real-World Marine Diesel Transient Duty-Cycles," EPA memo from Matt Spears to Mike Samulski, October 15, 1999, Docket A-2000-01, Document II-B-09.

11. Memorandum from Mark Wolcott to Charles Gray, "Ambient Temperatures Associated with High Ozone Concentrations," U.S. Environmental Protection Agency, September 6, 1984, Docket A-2000-01, Document II-B-06.

12. Smith, M., "Marine Diesel Engine Testing," Prepared by Southwest Research Institute for the U.S. EPA, Contract # 68-C-98-169, WA 0-7, September 1999, Docket A-2000-01, Document II-A-26.

13. SAE J1937 (reaffirmed JAN1995), "Engine Testing with Low-Temperature Charge Air-Cooler Systems in a Dynamometer Test Cell," SAE Recommended Practice, Docket A-2000-01, Document II-A-62.

14. Annex VI of MARPOL 73/78, "Technical code of control of Emissions of Nitrogen Oxides for Marine Diesel Engines," October 22, 1997, Docket A-2000-01, Document II-A-25.

15. "Emission Factors for Compression Ignition Nonroad Engines Operated on No. 2 Highway and Nonroad Diesel Fuel," U.S. Environmental Protection Agency, EPA420-R-98-001, March 1998, Docket A-2000-01, Document IV-A-73.

16. "Emission Data and Procedures for Large SI Engines," EPA memorandum from Alan Stout and Chuck Moulis to Docket A-2000-01, January 2, 2001, EPA420-F-00-050, Document II-B-05.

17. "Evaluation of Emissions Durability of Off-Road LPG Engines Equipped with Three-Way Catalysts," by Vlad Ulmet, Southwest Research Institute, SwRI 08.03661 & 08.03377, November 2000, (Docket A-2000-01, document II-A-07). This document is available through the National Technical Information Society at (703) 605-6000 (order number PB2002-101191).

18. The Mazda and GM engines are from SwRI 08.03661 & 08.03377, November 2000 (Docket A-2000-01, document II-A-07). Engine B and Engine E are from "Three-Way Catalyst Technology For Off-Road Equipment Powered by Gasoline and LPG Engines," by Jeff White et al, Southwest Research Institute, SwRI 8778, April 1999, (Docket A-2000-01, document II-A-08).

19."Durability Experience with Electronic Controlled CNG and LPG Engines," A. Lawson et al., February 2, 2000, Docket A-2000-01, Document II-D-2.

20."Exhaust Controls Available to Reduce Emissions from Nonroad Heavy-Duty Engines," by Kevin Brown, Engine Control Systems, in *Clean Air Technology News*, Winter 1997, Docket A-2000-01, Document II-A-2.

21. "Case Study: The Results of IMPCO's GM 3.0 liter Certified Engine Program," presented by Josh Pietak, February 2, 2000, A-2000-01, Document II-D-11.

22.See SwRI 08.03661 & 08.03377, November 2000 for a further description of the catalyst damage observed, (Docket A-2000-01, document II-A-07).

23."Emission Modeling for Recreational Vehicles," EPA memorandum from Linc Wehrly to Docket A-98-01, November 13, 2000, Document IV-B-06.

24. “Development and Validation of a Snowmobile Engine Emission Test Procedure,” Jeff J. White, Southwest Research Institute and Christopher W. Wright, Arctic Cat, Inc., SAE paper 982017, September, 1998, Docket A-2000-01, Document II-A-66.

25. 61 FR 52088, October 4, 1996.

26. Letter to Linc Wehrly from Phillip D. McDowell, Docket A-2000-01, Document IV-D-184.

27. www.arb.ca.gov/msprog/spillcon/reg.htm, Updated March 26, 2001, Copy of linked data reports available in Docket A-2000-01, Document IV-A-09.

28. “Permeation Rates of Small Off Road Engine High-Density Polyethylene Fuel Tanks (April 2001 Testing), June 8, 2001, California Air Resources Board, Docket A-2000-01, Document IV-A-101.

29. “Permeation Rates of Small Off Road Engine High-Density Polyethylene Fuel Tanks (February 2001 Testing), June 8, 2001, California Air Resources Board, Docket A-2000-01, Document IV-A-100.

30. “Permeation Rates of High-Density Polyethylene Fuel Tanks (June 2001), June 12, 2001, California Air Resources Board, Docket A-2000-01, Document IV-A-99.

31. Email from Jim Watson, California Air Resources Board, to Phil Carlson, U.S. EPA, “Early Container Data,” August 29, 2002, Docket A-2000-01, Docket No. IV-A-103.

32. Lockhart, M., Nulman, M., Rossi, G., “Estimating Real Time Diurnal Permeation from Constant Temperature Measurements,” SAE Paper 2001-01-0730, 2001, Docket A-2000-01, Document IV-A-21.

33. Hopf, G., Ries, H., Gray, E., “Development of Multilayer Thermoplastic Fuel Lines with Improved Barrier Properties,” SAE Paper 940165, 1994, Docket A-2000-01, Document IV-A-22.

34. Nulman, M., Olejnik, A., Samus, M., Fead, E., Rossi, G., “Fuel Permeation Performance of Polymeric Materials,” SAE Paper 2001-01-1999, 2001, Docket A-2000-01, Document IV-A-23.

35. SAE Recommended Practice J30, “Fuel and Oil Hoses,”June 1998, Docket A-2000-01, Document IV-A-92.

36. www.arb.ca.gov/msprog/spillcon/reg.htm, Updated March 26, 2001, Copy of linked data reports available in Docket A-2000-01, Document IV-A-09.

37. Email from Jim Watson, California Air Resources Board, to Phil Carlson, U.S. EPA, “Early Container Data,” August 29, 2002, Docket A-2000-01, Docket No. IV-A-103.

38. “Durability Testing of Barrier Treated High-Density Polyethylene Small Off-Road Engine Fuel Tanks,” California Air Resources Board, June 21, 2002, Docket A-2000-01, Document IV-

A-77.

39. Conversation between Mike Samulski, U.S. EPA and Tom Schmoyer, Sulfo Technologies, June 17, 2002.

40. "Resin and Additives - SO3 Compatible," Email from Tom Schmoyer, Sulfo Technologies to Mike Samulski and Glenn Passavant, U.S. EPA, June 19, 2002, Docket A-2000-01, Document IV-A-40.

41. Email from Jim Watson, California Air Resources Board, to Mike Samulski, U.S. EPA, "Attachment to Resin List," August 30, 2002, Docket A-2000-01, Document IV-A-102.

42. Walles, B., Nulford, L., "Five Year Durability Tests of Plastic Gas Tanks and Bottles with Sulfonation Barrier," Coalition Technologies, LTD, for Society of Plastics Industry, January 15, 1992, Docket A-2000-01, Document IV-A-76.

43. Kathios, D., Ziff, R., "Permeation of Gasoline and Gasoline-Alcohol Fuel Blends Through High-Density Polyethylene Fuel Tanks with Different Barrier Technologies," SAE Paper 920164, 1992, Docket A-2000-01, Document II-A-60.

44. www.arb.ca.gov/msprog/spillcon/reg.htm, Updated March 26, 2001, Copy of linked data reports available in Docket A-2000-01, Document IV-A-09.

45. "Permeation Rates of Blitz Fluorinated High Density Polyethylene Portable Fuel Containers," California Air Resources Board, April 5, 2002, Docket A-2000-01, Document IV-A-78.

46. Email from Jim Watson, California Air Resources Board, to Phil Carlson, U.S. EPA, "Early Container Data," August 29, 2002, Docket A-2000-01, Docket No. IV-A-103.

47. www.pensteel.co.uk/light/smp/fluorination.htm. A copy of this site is available in Docket A-2000-01, Document IV-A-86.

48. "Durability Testing of Barrier Treated High-Density Polyethylene Small Off-Road Engine Fuel Tanks," California Air Resources Board, June 21, 2002, Docket A-2000-01, Document IV-A-77.

49. Kathios, D., Ziff, R., "Permeation of Gasoline and Gasoline-Alcohol Fuel Blends Through High-Density Polyethylene Fuel Tanks with Different Barrier Technologies," SAE Paper 920164, 1992, Docket A-2000-01, Document II-A-60.

50. "Selar RB Technical Information," Faxed from David Zang, Dupont, to Mike Samulski, U.S. EPA on May 14, 2002, Docket A-2000-01, Document IV-A-88.

51. Fead, E., Vengadam, R., Rossi, G., Olejnik, A., Thorn, J., "Speciation of Evaporative Emissions from Plastic Fuel Tanks," SAE Paper 981376, 1998, Docket A-2000-01, Document

IV-A-89.

52. E-mail from Alan Dubin, Ticona, to Mike Samulski, U.S. EPA, “Fuel Permeation Chart and Aggressive Fuels Brochure,” July 31, 2002, Docket A-2000-01, Document IV-A-97.

53. SAE Recommended Practice J2260, “Nonmetallic Fuel System Tubing with One or More Layers,”1996, Docket A-2000-01, Document IV-A-18.

54. SAE Recommended Practice J30, “Fuel and Oil Hoses,” June 1998, Docket A-2000-01, Document IV-A-92.

55. “Visit to Dyneon on June 12, 2002,” Memorandum from Mike Samulski, U.S. EPA to Docket A-2000-01, June 17, 2002, Docket A-2000-01, Document IV-E-31.

56. “Meeting with Avon on June 27, 2002,” Memorandum from Mike Samulski, U.S. EPA to Docket A-2000-01, August 6, 2002, Docket A-2000-01, Document IV-E-33.

57. “Meeting with Avon on June 27, 2002,” Memorandum from Mike Samulski, U.S. EPA to Docket A-2000-01, August 6, 2002, Docket A-2000-01, Document IV-E-33.

58. Akron Rubber Development Laboratory, “TEST REPORT; PN# 49503,” Prepared for the U.S. EPA, September 3, 2002, Docket A-2000-01, Document IV-A-106.

59. Hopf, G., Ries, H., Gray, E., “Development of Multilayer Thermoplastic Fuel Lines with Improved Barrier Properties,” SAE Paper 940165, 1994, Docket A-2000-01, Document IV-A-22.

60. Stahl, W., Stevens, R., “Fuel-Alcohol Permeation Rates of Fluoroelastomers, Fluoroplastics, and Other Fuel Resistant Materials,” SAE Paper 920163, 1992, Docket A-2000-01, Document IV-A-20.

61. “Visit to Dyneon on June 12, 2002,” Memorandum from Mike Samulski, U.S. EPA to Docket A-2000-01, June 17, 2002, Docket A-2000-01, Document IV-E-31.

62. Goldsberry, D., “Fuel Hose Permeation of Fluoropolymers,” SAE Paper 930992, 1993, Docket A-2000-01, Document IV-A-91.

63. Tuckner, P., Baker, J., “Fuel Permeation Testing Using Gravimetric Methods,” SAE Paper 20001-01-1096, 2000, Docket A-2000-01, Document IV-A-96.

64. Nulman, M., Olejnik, A., Samus, M., Fead, E., Rossi, G., “Fuel Permeation Performance of Polymeric Materials,” SAE Paper 2001-01-1999, 2001, Docket A-2000-01, Document IV-A-23.

65. Duchesne, D., Hull, D., Molnar, A., “THV Fluorothermoplastics in Automotive Fuel Management Systems,” SAE Paper 1999-01-0379, 1999, Docket A-2000-01, Document IV-A-90.

66. Nulman, M., Olejnik, A., Samus, M., Fead, E., Rossi, G., “Fuel Permeation Performance of Polymeric Materials,” SAE Paper 2001-01-1999, 2001, Docket A-2000-01, Document IV-A-23.

67. Nulman, M., Olejnik, A., Samus, M., Fead, E., Rossi, G., “Fuel Permeation Performance of Polymeric Materials,” SAE Paper 2001-01-1999, 2001, Docket A-2000-01, Document IV-A-23.

68. “Visit to Dyneon on June 12, 2002,” Memorandum from Mike Samulski, U.S. EPA to Docket A-2000-01, June 17, 2002, Docket A-2000-01, Document IV-E-31.

69. Facsimile from Bob Hazekamp, Top Dog Systems, to Mike Samulski, U.S. EPA, “Permeation of Polyurethane versus THV Materials @ 60°C,” January 14, 2002, Docket A-2000-01, Document II-B-30.

70. Duchesne, D., Hull, D., Molnar, A., “THV Fluorothermoplastics in Automotive Fuel Management Systems,” SAE Paper 1999-01-0379, 1999, Docket A-2000-01, Document IV-A-90.

71. Draft SAE Information Report J1769, “Test Protocol for Evaluation of Long Term Permeation Barrier Durability on Non-Metallic Fuel Tanks,” Docket A-2000-01, Document IV-A-24.

72. SAE Recommended Practice J30, “Fuel and Oil Hoses,” June 1998, Docket A-2000-01, Document IV-A-92.

73. SAE Recommended Practice J2260, “Nonmetallic Fuel System Tubing with One or More Layers,”1996, Docket A-2000-01, Document IV-A-18.

Chapter 5: Costs of Control

This chapter describes our approach to estimating the cost of complying with emission standards. We start with a general description of the approach to estimating costs, then describe the technology changes we expect and assign costs to them. We also present an analysis of the estimated aggregate cost to society.

5.1 Methodology

We developed the costs for individual technologies using information provided by ICF, Incorporated and Arthur D. Little, as cited below with further consideration to any information provided in the public comments. The technology characterization and cost figures reflect our current best judgment based on engineering analysis, information from manufacturers, and the published literature. The analysis combines cost figures including markups to the retail level.

Costs of control include variable costs (for incremental hardware costs, assembly costs, and associated markups) and fixed costs (for tooling, R&D, and certification). Variable costs are marked up at a rate of 29 percent to account for the engine manufacturers' overhead and profit.[1] For technologies sold by a supplier to the engine manufacturers, an additional 29 percent markup is included for the supplier's overhead and profit. All costs are in 2001 dollars.

The analysis presents an estimate of costs that will occur in the first year of new emission standards and the corresponding long-term costs. Long-term costs decrease due to two principal factors. First, fixed costs are assessed for five years, after which they are fully amortized and are therefore no longer part of the cost calculation. Second, manufacturers are expected to learn over time to produce the engines with the new technologies at a lower cost. Because of relatively low sales volumes, manufacturers are less likely to put in the extra R&D effort for low-cost manufacturing. Learning will occur in two basic ways. As manufacturers produce more units, they will make improvements in production methods to improve efficiency. One example of this is automation. The second way learning occurs is materials learning where manufacturers reduce scrap. Scrap includes units that are produced but rejected due to inadequate quality and material scrap left over from the manufacturing process. As production starts, assemblers and production engineers will then be expected to find significant improvements in fine-tuning the designs and production processes. Consistent with analyses from other programs, we reduce estimated variable costs by 20 percent beginning with the third year of production and an additional 20 percent beginning with the sixth year of production.[2]

We believe it is appropriate to apply this factor here, given that the industries are facing emission regulations for the first time and it is reasonable to expect learning to occur with the experience of producing and improving emission-control technologies. Manufacturers do not have significant experience with most of the emissions controls that are anticipated for meeting the standards contained in the Final Rule. In cases where manufacturers have used certain technologies, such as with 4-stroke engines, they have not been required to meet standards. They will be manufacturing new 4-stroke engines or purchasing and installing 4-stroke engines in new models. Learning will likely occur for these models. Some manufacturers, especially in the youth ATV market do not have experience with 4-stroke engines. Also, the 4-strokes will need to be made to meet emissions standards. We believe that learning for these models will continue to take place.

Many of the engine technologies available to manufacturers to control emissions also have the potential to significantly improve engine performance. This is clear from the improvements in automotive technologies. As cars have continually improved emission controls, they have also greatly improved fuel economy, reliability, power, and a reduced reliance on regular maintenance. Similarly, the fuel economy improvements associated with converting from two-stroke to four-stroke engines is well understood. We attempt to quantify these expected improvements, as we describe for each type of engine below.

Even though the analysis does not reflect all the possible technology variations and options that are available to manufacturers, we believe the projections presented here provide cost estimates representative of the different approaches manufacturers may ultimately take. We expect manufacturers in many cases to find and develop approaches to achieve the emission standards at a lower cost than we describe in this analysis.

5.2 Cost of Emission Controls by Engine/Vehicle Type

5.2.1 Recreational Marine Diesel Engines

We have developed cost estimates for diesel engine technologies for several different applications in a series of reports.[3,4,5] This analysis adapts these existing cost estimates for recreational marine diesel engines with separate estimates for three different sizes of engines.

Recreational marine diesel engines invariably have counterpart engine models used for commercial application. Manufacturers will design, certify, and manufacture these commercial models to meet emission standards. The analysis projects that manufacturers will comply with the new emission standards generally by applying the same technologies for both commercial and recreational engines. The remaining effort to meet emission standards with the recreational models is therefore limited to applying new or improved hardware and conducting sufficient R&D to integrate the new technologies into marketable products. The analysis therefore does not consider fixed costs to develop the individual technologies separately.

One area where recreational engine designs differ is in turbocharging and aftercooling. To reach peak performance, recreational engines typically already use optimized turbochargers and seawater aftercooling, which offer the greatest potential for controlling NOx emissions.

We estimate the total cost impact of new emission standards by considering the cost of each of the anticipated technologies. The following paragraphs describe these technologies and their application to recreational marine engines. The analysis then combines these itemized costs into a composite estimate for the range of marine engines affected by the rulemaking.

Table 5.2.1-1 also includes information on product offerings and sales volumes, which is needed to calculate amortized fixed costs for individual engines. Estimated sales and product offerings were compiled from the PSR database based on historical 1997 information.

Table 5.2.1-1
Recreational Marine Diesel Engine Categories for Estimating Costs

Engine Power Ranges (kW)	Nominal Engine Power (kW)	Annual Sales	Models	Average Sales per Model
37 - 225	100	11,600	17	675
225 - 560	400	3,560	15	250
560 +	750	397	6	70

Manufacturers are expected to develop engine technologies not only to reduce emissions, but also to improve engine performance. While it is difficult to take into account the effect of ongoing technology development, EPA is concerned that assessing the full cost of the anticipated technologies as an impact of new emission standards inappropriately excludes from consideration the expected benefits for engine performance, fuel consumption, and durability.[dd] Short of having sufficient data to predict the future with a reasonable degree of confidence, we face the need to devise an alternate approach to quantifying the true impact of the new emission standards. As an attempt to take this into account, we present the full cost of the control technologies in this chapter, then apply an adjustment to some of these costs for calculating the cost-per-ton of the emission standards, as described in Chapter 7.

5.2.1.1 Fuel Injection Improvements

All engines are expected to see significant improvements in their fuel injection systems. The smaller engines will likely undergo incremental improvements to existing unit injector designs. The analysis projects that engines rated over 600 kW will use common rail injection technology, which greatly increases the flexibility of tailoring the injection timing and profile to varying modes of operation. Better control of injection timing and increased injection pressure contribute to reduced emissions. Table 5.2.1-2 shows the estimated costs for these fuel injection improvements.

[dd]While EPA does not anticipate widespread, marked improvements in fuel consumption, small improvements on some engines may occur.

Table 5.2.1-2: Fuel Injection Improvements

	100 kW	400 kW	750 kW
Component costs	$63	$98	$205
Assembly, markup, and warranty	$32	$46	$59
Composite Unit Cost	$95	$144	$264

5.2.1.2 Engine Modifications

Manufacturers will be optimizing basic engine parameters to control emissions while maintaining performance. Such variables include routing of the intake air, piston crown geometry, and placement and orientation of injectors and valves. Most of these variables affect the mixing of air and fuel in the combustion chamber. Small changes in injection timing are also considered in this set of modifications. We expect, however, that manufacturers will complete this work for commercial marine diesel engines, so that the remaining effort will be focused on fine-tuning designs for turbocharger matching and other calibration-related changes. Fixed costs are amortized over a five-year period, using the sales volumes developed in Table 5.2.1-1, with forward discounting incorporated to account for manufacturers incurring these costs before the emission standards begin to apply. Table 5.2.1-3 shows the estimated per-engine costs for these modifications. These costs include the consideration manufacturers must give to offsetting any crankcase emissions routed to the exhaust. There is no estimated long-term cost to the engine modifications because manufacturers can fully recover the fixed costs, and we don't expect any increase in variable costs as a result of these improvements.

Table 5.2.1-3: Engine Modifications

	100 kW	400 kW	750 kW
Total fixed costs	$200,000	$200,000	$200,000
Fixed cost per engine	$72	$195	$697
Composite Unit Cost	$72	$195	$697

As described in the preamble to the final rule, the manufacturers are responsible to comply with emissions at any speed and load that can occur on a vessel. We believe that is not appropriate to consider additional costs for manufacturers to comply with these "off-cycle" requirements. This is because we expect that manufacturers can manage engine operation to avoid unacceptable variation in emission levels by more effectively using the technologies that will be used to meet the emission limits more broadly, rather than by use of additional hardware. For example, manufacturers can adjust fuel injection parameters to avoid excessive emissions. The split-zone approach described in Chapter 4 is designed to accommodate normal variation in emission levels at different operating points. This approach involves no additional variable cost. The estimated R&D expenditures reflect the time needed to address this.

5.2.1.3 Certification and Compliance

We have significantly reduced certification procedural requirements in recent years, but manufacturers are nevertheless responsible for generating the necessary test data and other information to demonstrate compliance with emission standards. Table 5.2.1-4 lists the expected costs for different sizes of engines, including the amortization of those costs over five years of engine sales. Estimated certification costs are based on two engine tests and $10,000 worth of engineering and clerical effort to prepare and submit the required information.

Until engine designs are significantly changed, engine families can be recertified each year using carryover of the original test data. Since these engines are currently not subject to any emission requirements, the analysis includes a cost to recertify an upgraded engine model every five years.

Costs for production line testing are summarized in Table 5.2.1-5. These costs are based on testing 1 percent of total estimated sales, then distributing costs over the fleet. Listed costs for engine testing presume no need to build new test facilities, since we may waive production-line testing requirements for small-volume production. Few manufacturers, if any, will therefore need to build new test facilities.

Table 5.2.1-4: Certification

	100 kW	400 kW	750 kW
Total fixed costs	$30,000	$30,000	$40,000
Fixed cost per engine	$12	$29	$139
Composite Unit Cost	$12	$29	$139

Table 5.2.1-5: Costs for Production Line Testing

	100 kW	400 kW	750 kW
Cost per test	$10,000	$10,000	$15,000
Testing rate	1 %	1 %	1 %
Cost per engine	$100	$100	$150

5.2.1.4 Total Engine Costs

These individual cost elements can be combined into a calculated total for new emission standards by assessing the degree to which the different technologies will be deployed. As shown in Table 5.2.1-6, estimated costs for complying with the emission standards increase with increasing power ratings. We expect each of the listed technologies to apply to all the engines that need to meet the new emission standards. Estimated first-year cost impacts range from $300 to $1,300 for the different engine sizes, while long-term cost estimates range from $170 to $460.

Characterizing these estimated costs in the context of their fraction of the total purchase price and life-cycle operating costs is helpful in gauging the economic impact of the new standards. The estimated first-year cost increases for all engines are at most 2 percent of estimated engine prices, with even lower long-term effects, as described above.

Table 5.2.1-6: Diesel Engine Costs

	100 kW	400 kW	750 kW
Fuel injection upgrade	$95	$144	$264
Engine modifications	$72	$195	$697
Certification + PLT	$111	$129	$289
Total Engine Cost, year 1	$278	$468	$1,251
Total Engine Cost, year 6	$172	$221	$459

5.2.1.5 Marine Diesel Aggregate Costs

The above analyses developed incremental per-vessel cost recreational marine diesel engines. Using these per-engine costs and projections of future annual sales, we have estimated total aggregate annual costs for emission standards. The aggregate costs are presented on a cash-flow basis, with hardware and fixed costs incurred in the year the vehicle is sold. Table 5.2.1-7 presents a summary of this analysis. As shown in the table, aggregate net costs stay between $3 million and $6 million.

Table 5.2.1-7
Summary of Annual Aggregate Costs for Marine Diesel Engines (millions of dollars)

	2006	2010	2015	2020	2025
Total Costs	$6.2	$7.6	$2.8	$3.1	$3.4

To project annual sales, we started with the 1998 population estimates presented in Chapter 6. We then used the engine turnover rates and growth estimates to calculate annual sales. Table 5.2.1-8 provides a summary of the sales estimates used in the aggregate cost analysis.

Table 5.2.1-8
Estimated Annual Sales of Recreational Marine Diesel Engines

Engine Power Range (kW)	2000	2006	2010	2020
37 - 225	11,600	13,700	15,200	18,700
225 - 560	3,560	4,200	4,620	5,690
560 +	397	469	517	636

To calculate annual aggregate costs, the sales estimates have been multiplied by the per-unit costs discussed above. These calculations take into consideration vehicle sales and scrappage rates. The year-by-year results of the analysis are provided in Chapter 7.

5.2.2 Large Industrial Spark-Ignition Engines

We estimated the cost of upgrading LPG-fueled and gasoline-fueled Large SI engines. We developed the costs for individual technologies in cooperation with ICF, Incorporated and Arthur D. Little.[6] The analysis combines these individual figures into a total estimated cost for each type of engine, including markups to the retail level. A composite cost based on the mix of engine types provides an estimated industry-wide estimate of the per-engine cost impact.

Gasoline-fueled Large SI engines continue to rely on traditional carburetor designs rather than incorporating the automotive technology innovations introduced to address emission controls. Since natural gas- and LPG-fueled engines use comparable technologies, the analysis presents a single set of costs for both fuels.

The anticipated technology development is generally an outgrowth of automotive technologies. Over the last thirty years, engineers in the automotive industry have made great strides in developing new and improved approaches to achieve dramatic emission reductions with high-performing engines. In more recent years, companies have started to offer these same technologies for industrial applications. Fundamental to this technology development is the electronically controlled fuel system and catalytic converters.

Electronically controlled fuel systems allow manufacturers to more carefully meter fuel into the combustion chambers. This gives the design engineer an important tool to better control power and emission characteristics over the whole range of engine operation. Careful control of air-fuel ratio is also essential for effective catalyst conversion. The catalyst reduces the concentration of pollutant gases in the exhaust stream. We also consider development time to redesign the combustion chamber and intake air routing, as well as to combine the new control technologies and optimize engine calibrations. We include these efforts under the total R&D costs for each engine.

Gasoline engines can use either throttle-body or port-fuel injection. Manufacturers can likely reach the targeted emission levels using simpler throttle-body systems. However, the performance advantages and the extra assurance for full-life emission control from the more advanced port-fuel injection systems offer a compelling advantage. The analysis therefore projects that all gasoline engines will use port-fuel injection. The analysis does not take into account the performance advantages of port-fuel injection and therefore somewhat overestimates the cost impact of adopting new emission standards.

Gaseous-fuel engines have very different fuel metering systems due to the fact that LPG and natural gas evaporate readily at typical ambient temperatures and pressures. Manufacturers of these engines face a choice between continuing with conventional mixer technology and upgrading to injection systems. We are aware that manufacturers are researching gaseous injection systems, but we believe mixer technology will be sufficient to meet the standards. All the data supporting the feasibility of emission standards for LPG engines is based on engines using mixer technology.

5.2.2.1 Engine Technology

Tables 5.2.2-1 and 5.2.2-2 show the estimated costs of upgrading each of the engine types. The cost figures are in the form of retail-price equivalent for an individual engine. The tables include individual cost estimates of the various components involved in converting a baseline engine to comply with emission standards. The cost of the catalyst is based on a precious metal loading of 2.8 g/liter (primarily palladium, with small amounts of platinum and rhodium) and a catalyst volume 60 percent of total engine displacement.

The analysis incorporates a cost for potential warranty claims related to the new technologies by adding 5 percent of the increase in hardware costs. The industry has gained enough experience with electronic fuel systems that we expect a relatively low rate of warranty claims for them. Catalysts have been used for many years, but not in Large SI applications, so these technologies may cause a somewhat higher rate of warranty claims.

Even without EPA emission standards, manufacturers will conduct the research and development needed to meet the 2004 emission standards in California. The R&D impact of new EPA standards is therefore limited to the additional burden of complying with the 2007 requirements. Estimated costs for research and development are $175,000 for each engine family. This is based on about six months of time for an engineer and a technician on each fuel type for each engine family. We expect initial efforts to be more extensive, but cumulative learning should reduce per-family development costs for subsequent models. These fixed costs are increased by 7 percent to account for forward discounting, since manufacturers incur these costs before the new standards apply. Redesigning the first engine model will likely require significantly more time than this, but we expect the estimated level of R&D to be appropriate as an average level for the range of models in a manufacturer’s product line.

Table 5.2.2-2 presents separate costs for water-cooled and air-cooled gasoline engines. While many of the components are the same, the main differences include (1) a single fuel injector and simpler intake manifold for throttle-body injection, (2) smaller sales volume for amortizing fixed costs, and (3) substantial fixed costs for meeting the 2004 standards. Air-cooled engines are generally not certified already in California, largely because most applications involving air-cooled Large SI engines are preempted from California ARB's emission standards. To take this into account, we have added an estimate of $500,000 for R&D and $100,000 for tooling costs per engine family. Discounting these costs forward two years and amortizing over five years of sales results in an additional cost of $166 per air-cooled engine.

Table 5.2.2-1
Estimated Costs for an LPG-fueled Large SI Engine

	Baseline	Controlled
Hardware Cost to Manufacturer		
Regulator/throttle body	$50	$65
Intake manifold	$37	$37
Positive crankcase ventilation		$3
Fuel filter w/ lock-off system	$15	$15
LPG vaporizor	$75	$75
Governor	$40	$60
Converter temperature control valve		$15
Oxygen sensor		$19
ECM		$100
Wiring/related hardware		$42
Fuel system total	$217	$431
Catalyst/muffler		$229
Muffler	$45	$0
Total Hardware Cost	$262	$660
Markup @ 29%	$76	$191
Warranty markup @5%		$20
Total component costs	$338	$871
2004 Fixed costs		$0
2004 Incremental costs		$533
Fixed Cost to Manufacturer		
2007 R&D costs		$175,000
Units/yr.		2,000
Amortization period (7 % discounting)		5
2007 Fixed cost/unit	$0	$26
2007 Evap costs	$0	$0
2007 Incremental costs		$0

Table 5.2.2-2
Estimated Per-Engine Costs for Gasoline-Fueled Large SI Engines

	Water-cooled		Air-cooled	
	Baseline	Controlled	Baseline	Controlled
Hardware Cost to Manufacturer				
Carburetor	$51	$0	$51	$0
Injectors (each)		$17		$19
Number of injectors		4		1
Pressure Regulator		$11		$11
Fuel filter	$3	$4	$3	$4
Intake manifold	$35	$50	$35	$37
Positive crankcase ventilation		$3		$3
Fuel rail		$13		—
Throttle body/position sensor		$60		$76
Fuel pump	$15	$30	$15	$26
Oxygen sensor		$19		$19
ECM		$150		$140
Governor	$40	$60	$40	$60
Air intake temperature sensor		$5		$5
Manifold air pressure sensor		$11		$11
Injection timing sensor		$12		$12
Wiring/related hardware		$42		$42
Fuel system total	$144	$538	$144	$465
Catalyst/muffler		$229		$229
Muffler	$45		$45	
Total Hardware Cost	$189	$767	$189	$694
Markup @ 29%	$55	$222	$55	$201
Warranty markup @5%		$29		$25
Total Component Costs	$244	$1,018	$244	$920
2004 Fixed costs		$0		$600,000
2004 Fixed cost/unit		$0		$166
2004 Incremental costs		$775		$842
Fixed Cost to Manufacturer				
2007 R&D Costs		$175,000		$175,000
Units/yr.		1,750		1,000
Amortization period (7 % discounting)		5		5
2007 Fixed cost/unit		$30		$52
2007 Evap costs	$0	$13	$0	$13
2007 Incremental costs		$43		$65

In addition to these estimated costs for addressing exhaust emissions, we have analyzed the costs associated with reducing evaporative emissions from gasoline-fueled engines and vehicles. This effort consists of three primary areas—permeation, diurnal, and boiling.

To reduce permeation losses, we expect manufacturers to upgrade plastic or rubber fuel lines to use automotive-grade materials. These fuel lines are readily available at a cost premium of about $1 per linear foot. If an installed engine has an average of four feet of fuel line, this translates into an increased cost of $4 per engine.

The standard related to diurnal emissions can be met with a fuel cap that seals the fuel tank, relieving pressure as needed to prevent the tank from bursting or collapsing. The estimated cost of upgrading to such a fuel cap is conservatively set at $8, based on the aftermarket cost of comparable automotive fuel caps. Such caps would be expected to cost much less as an original equipment upgrade of an existing cap.

Many Large SI engines are installed in equipment in a way that poses little or no risk of fuel boiling during engine operation. A few models are configured in a way that causes this to be a possibility, at least under extreme conditions. Preventing fuel boiling is primarily a matter of isolating the fuel tank from heat sources, such as the engine compartment and the exhaust pipe. Some additional material may be needed to reduce heat exposure, such as a simple metal shield or a fiberglass panel. Given several years to redesign engines and equipment, we believe that manufacturers can readily incorporate such changes into their ongoing R&D programs. To account for several hours of engineering effort and a small amount of material, we estimate that these costs averaged over the whole set of gasoline-fueled engines will come to about $1 per engine.

5.2.2.2 Operating Cost Savings

Introducing electronic closed-loop fuel control will significantly improve engine operation, with corresponding cost savings, in three areas— reduced fuel consumption, less frequent oil changes and tuneups, and delayed time until rebuild.

It may also be appropriate to quantify the benefit of longer total engine lifetimes. For example, passenger cars with low-emission engine technologies last significantly longer than they did before manufacturers developed and applied these technologies. In addition, engine performance (responsiveness, reliability, engine warm-up, etc.) will also improve with the new technologies. However, these benefits are more difficult to quantify and the analysis therefore does not take them into account.

Fuel consumption rates will improve as manufacturers no longer design engines for operation in fuel-rich conditions. Some current systems already operate at somewhat leaner air-fuel ratios than in previous years, but even in these cases, engines generally revert to richer mixtures when accelerating. Closed-loop fuel systems generally operate close to stoichiometry, which improves the engine's efficiency of converting the fuel energy into mechanical work. Information in the docket, including development testing, engineering projections, and user testimony, indicates an estimated 20-percent reduction in fuel consumption rates.[7,8,9] Table 5.2.2-3 shows the value of the estimated fuel savings. These values and calculations are generally based on our NONROAD emissions model. Since the NONROAD model does not account separately for air-cooled engines, calculated fuel savings are based on information we received during the comment period.

Table 5.2.2-3: Estimated Fuel Savings from Large SI Engines

	LPG	Natural gas	Gasoline–water-cooled	Gasoline–air-cooled
Horsepower	66	64	52	60
Load factor	0.39	0.49	0.58	0.58
Annual operating hours, hr/yr	1,368	1,164	534	1,000
Lifetime, yr	12	13	12	3
Baseline bsfc, lb/hp-hr	0.507	0.507	0.605	1.10
Improved bsfc, lb./hp-hr	0.406	0.406	0.484	0.88
Fuel density	4.2 lb./gal	0.05 g./ft^3	6.1 lb./gal	6.1 lb./gal
Fuel cost	$0.60/gal	$2.17/1000 ft^3	$1.10/gal	$1.10/gal
Annual fuel saved (gal/yr)	845	—	321	1,233
Annual fuel savings ($/yr)	$507	$160	$353	$1,357
Lifetime Fuel Savings (NPV)	$4,333	$1,427	$3,038	$3,810

In addition to the fuel savings, we expect Large SI engines to see significant improvements in reliability and durability. Open-loop fueling systems in uncontrolled engines are prone to drifting calibrations as a result of varying fuel quality, wear in engine components, changing ambient conditions, and other factors. Emission-control systems that operate with a feedback loop to compensate for changing conditions for a near-constant air-fuel ratio significantly reduces the following problems.

-incomplete (and eventually unstable) combustion
-absorption of fuel in lubricating oil
-deposits on valves, spark plugs, pistons, and other engine surfaces
-increased exhaust temperatures

Automotive engines clearly demonstrate that modern fuel systems reduce engine wear and the need for repairs.

This analysis incorporates multiple steps to take these anticipated improvements into account. First, oil change intervals are estimated to increase by 15 percent. Reduced fuel loading in the oil (and other improvements such as piston ring design) can significantly extend its working life. Similarly, tune-up intervals are estimated to increase by 15 percent. This results largely from avoiding an accumulation of deposits on key components, which allows for longer operation between regularly scheduled maintenance. Third, we estimate that engines will last 15 percent longer before needing overhaul. The reduced operating temperatures and generally reduced engine wear associated with closed-loop fuel systems account for this extended lifetime to rebuild. These quantitative estimates of maintenance-related savings are derived from observed changes in automotive performance when upgrading from carburetion to fuel injection. Table 5.2.2-4 summarizes the details of the methodology for converting these maintenance improvements into estimated cost savings over the lifetime of the engines.

Table 5.2.2-4: Maintenance

	LPG/ natural gas	Gasoline
Baseline oil change interval (hrs)	200	150
Improved oil change interval (hrs)	230	172.5
Cost per oil change ($)	$30	$30
Baseline tune-up interval (hrs)	400	400
Improved tune-up interval (hrs)	460	460
Cost per tune-up ($)	$75	$75
Baseline rebuild interval (hrs)	7,000	5,000
Improved rebuild interval (hrs)	8,050	5,750
Rebuild cost ($)	$800	$800
Baseline lifetime maintenance cost	$2,902	$2,573
Improved lifetime maintenance cost	$2,681	$2,354
Lifetime maintenance savings (NPV)	$221	$219

These large estimated fuel and maintenance savings relative to the estimated incremental cost of producing low-emitting engines raise the question of why normal market forces have failed to induce manufacturers to design and sell engines with emission-control technologies on the basis of the expected performance improvements. Since forklifts are the strongly dominant application using Large SI engines, this question effectively applies specifically to forklifts. We have observed that forklift users generally see their purchase as an expense that doesn't add value to a company's product, whether that applies to manufacturing, warehouse, or retail facilities. While operating expenses require less internal justification or decision-making, purchasing new equipment involves extensive review and oversight by managers who are very sensitive to capital expenditures. This is reinforced by an April 2000 article in a trade publication, which quotes an engineering estimate of 20- to 40-percent improvement in fuel economy while stating that it is unclear whether purchasers will tolerate any increase in the cost of the product.[10] Market theory would predict that purchasers select products with technologies that result in the lowest net cost (with some appropriate discount for costs incurred over time). It seems that companies have historically focused on initial costs to the exclusion of potential cost savings over time, which would account for the lack of emission-control technologies on current sales of Large SI engines.

This priority given to initial cost therefore affects the competitive decisions of engine manufacturers, who will be less willing to take the business risk of developing a more costly product than its competitors, even if the product would eventually provide substantial savings to the purchaser. Also, the initial costs of changing designs and using new technologies can serve as a deterrent to including newer cost-efficient technologies in established engine types.

In addition to the engine improvements described above, the costs associated with controlling evaporative emissions would be offset by savings from retaining more fuel that can be used to power the engine. To estimate these costs, we compare the total emission reductions from diurnal, running loss, hot soak, and refueling emissions with the total gasoline-fueled engine population in 2030. The resulting reduction of 0.04 tons hydrocarbon per engine translates into estimated annual savings of $11. Spread over 13 years and discounted to the point of sale leads to a net present value of $98 saved.

5.2.2.3 Compliance Costs

We estimate that certification costs come to $70,000 per engine family. We expect manufacturers to combine similar engines using different fuels in the same family. This expands the size of engine families, but calls for several tests to complete the certification process for each family. This includes six engine tests and $10,000 worth of engineering and clerical effort to prepare and submit the required information. Until engine designs are significantly changed, engine families can be recertified each year using carryover of the original test data. This cost is therefore amortized over five years of engine sales, with an assumed volume of 3,000 engines per year from each engine family. This engine-family sales volume is larger than those presented for amortizing fixed costs above, because engine families will include multiple fuel types. The resulting cost for certification is $6 per engine. Since these engines are currently not subject to any EPA emission requirements, the analysis includes a cost to recertify an upgraded engine model every five years. Since manufacturers already need to submit data for California certification, they will incur most of these costs independent of EPA requirements.

Manufacturers must generally do production-line testing on a quarterly basis, but reduced testing rates apply if engine testing shows consistently good test results. Manufacturers must generate and submit this test data to comply with the requirements adopted by California ARB. The EPA requirement for production-line testing therefore adds no test burden to manufacturers. Even with a transient duty cycle for certification, manufacturers may rely on steady-state test procedures at the production line. We therefore fully expect that manufacturers will need only to send the “California” test data to EPA to satisfy requirements for production-line testing. The analysis therefore includes no cost for additional routine testing of production engines. In fact, manufacturers may pursue alternate methods to show that production engines comply with emission standards, which may lead to lower testing costs.

We may select up to 25 percent of a manufacturers’s engine families for in-use testing. This means that a manufacturer would need to have eight engine families for us to be able to select two engine families in a given year. Since this is likely to be a rare scenario, we project an annual testing rate of one engine family per year for each manufacturer to assess the cost of the in-use testing program. The analysis includes the cost of testing in-use engines on a dynamometer, which requires:

- engine removal and replacement ($4,000)

- transport ($1,000)
- steady-state and transient testing ($15,000)

Testing six engines and adding costs for administration and reporting of the testing program leads to a total cost of about $125,000 for an engine family. These costs can be spread over a manufacturer's total annual sales, which averages about 15,000 units for most companies. The resulting cost per engine is about $8.

As with production-line testing, we expect in-use emission testing to simultaneously satisfy California ARB and EPA requirements. In certain circumstances, however, we may use our discretion to direct a manufacturer to do in-use testing on an engine family separately from California ARB. Since we expect this to be the exception, this analysis likely overestimates the cost impact of adopting federal requirements to do in-use testing. In fact, manufacturers may reduce their compliance burden with the optional field-testing procedures. Table 5.2.2-5 shows the estimated costs from the various compliance programs.

In addition, we expect several manufacturers to upgrade testing facilities to allow for in-house measurement of emissions during transient engine operation. We generally expect each major manufacturer to equip one test cell with a new dynamometer and the associated controllers and analyzers. Installation of transient test cell would cost about $500,000. This consists of about $225,000 each for an electric dynamometer and the associated controllers, and $50,000 for a battery of sampling equipment and analyzers. An additional capital cost of $80 is estimated for precision calipers with digital readout to ensure dimensional accuracy of catalyst diameters. Dividing these costs over six engine families for five years leads to a calculated per-engine cost under $10.

Table 5.2.2-5
Cost of Compliance Programs

Compliance Program Element	Estimated Per-Engine Costs
Certification	$6
In-use testing	$8
Facility upgrade	$7
Total	$21

5.2.2.4 Total Costs

Table 5.2.2-6 presents the combined cost figures for the different engine types and calculates a composite cost based on their estimated distribution. The estimated 2004 costs are based on the adding component costs and compliance costs. No R&D cost is estimated for manufacturers to do additional development work beyond what is necessary to comply with

California ARB standards. Conversely, the estimated 2007 costs are based on R&D (and ongoing compliance costs), with no anticipated increase in component costs, except those related to reducing evaporative emissions. The estimated cost of complying with the emission standards is sizable, but the lifetime savings from reduced operating costs nevertheless more than compensate for the increased costs. Costs for gasoline engines are presented as a composite of air-cooled models (estimated 3 percent of total sales) and water-cooled models (estimated 20 percent of total sales).

Table 5.2.2-6
Estimated First-Year Cost Impacts of New Emission Standards

Standards	Engine Type	Sales Mix of Engine Types	Increased Production Cost per Engine*	Lifetime Operating Costs per Engine (NPV)
2004	LPG	68%	$550	$-4,330
	natural gas	9%	$550	$-1,650
	gasoline	23%	$800	$-3,140
	Composite	—	$605	$-3,815
2007	LPG	68%	$40	—
	natural gas	9%	$40	—
	gasoline	23%	$60	$-100
	Composite	—	$50	$-20

*The estimated long-term costs decrease by about 35 percent.

5.2.2.5 Large SI Aggregate Costs

The above analyses developed incremental per-vessel cost estimates for Large SI engines. Using these per-engine costs and projections of future annual sales, we have estimated total aggregate annual costs for the exhaust and evaporative emission standards. The aggregate costs are presented on a cash-flow basis, with hardware and fixed costs incurred in the year the vehicle is sold and fuel savings occurring as the engines are operated over their lifetimes. Table 5.2.2-7 presents a summary of this analysis. As shown in the table, aggregate costs generally range from $70 million to $90 million. Net costs decline as fuel savings continue to ramp-up as more vehicles meeting the standards are sold and used. Fuel savings are projected to more than offset the costs of the program starting by the second year of the program.

Table 5.2.2-7: Summary of Annual Aggregate Costs and Fuel Savings for Large SI Engines (millions of dollars)

	2004	2005	2010	2015	2020
Total Costs	$89	$91	$71	$73	$81
Fuel Savings	($53)	($103)	($326)	($421)	($472)
Net Costs	$36	($12)	($255)	($348)	($391)

To project annual sales, we started with the number of model year 2000 engines estimated by the NONROAD model for the 2000 calendar year. We then applied a growth rate of 3 percent of year 2000 sales (increasing by 3,900 units annually) to estimate future sales. Table 5.2.2-8 provides a summary of the sales estimates used in the aggregate cost analysis.

Table 5.2.2-8
Estimated Annual Sales of Large SI Engines

2000	2004	2010	2020
130,000	145,600	169,000	208,000

To calculate annual aggregate costs, the sales estimates have been multiplied by the per-unit costs. Annual fuel savings have been calculated based on the reduction in fuel consumption expected from the standards (as described in section 5.2.2.2 of this chapter) as calculated by the NONROAD model. The model takes into consideration vehicle sales and scrappage rates. The year-by-year results of the analysis are provided in Chapter 7.

5.2.3 Recreational Vehicles

5.2.3.1 Technologies and Estimated Costs

We estimated costs separately for snowmobiles, ATVs, and off-highway motorcycles. Individual technology costs were developed in cooperation with EPA by ICF Incorporated and Arthur D. Little - Acurex Environmental.[11] Any comments received on the rule were also evaluated and included where appropriate. Costs were prepared for a typical engine that falls within the displacement ranges noted below. Costing out multiple engine sizes allowed us to estimate significant differences in costs for smaller vs. larger engines. The costs include a mark-up to the retail level. This Chapter also provides a brief overview of the technologies, with more information provided in Chapter 4. Costs are provided for both the baseline technology and the new technology (e.g., a two-stroke engine and a four-stroke engine), with the cost of the change in technology due to the new standards being the increment between the two costs.

The R&D costs shown are average costs. The first engine line R&D cost is expected to be significantly higher but the costs would be distributed across the manufacturer's entire product line.[12] To account for any additional warranty cost associated with a change in technology, we have added 5 percent of the incremental hardware cost.[13]

As noted in section 5.1, fixed costs are spread over the first five years of sales for purposed of the cost analysis, with the exception of new facility costs for ATV testing which are spread over 10 years. We have used 10 years for amortization rather than 5 years because we believe it is more representative for a capital investment that will be used for at least that long a time period. We estimated that R&D and facility costs will be incurred three years prior to production on average and tooling and certification costs will be incurred one year prior to production. These fixed costs were then increased seven percent for each year prior to the start of production to reflect the time value on money.

To approximate average annual sales per engine line, we divided the total 2001 annual unit sales by estimated total number of engines lines industry-wide.[ee] Based on limited sales data from individual manufacturers provided to EPA on a confidential basis, there appears to be a large distinction in sales volume between small engine and large engine displacements for ATVs. The cost analysis accounts for this difference by using a larger annual sales rate per engine line for larger displacement ATVs, as shown below.

As noted below, the fuel savings over the life of the vehicle due to some of the projected technology changes can be substantial and for snowmobiles are projected to offset the cost of the emission controls. As discussed below, these fuel savings will occur because 2-stroke powerplants are inefficient and the changes needed to reduce hydrocarbons from these engines also improve fuel consumption. Because the fuel savings outweigh up front costs, one might question why manufacturers have continued to use 2-stroke engines. Manufacturers have not made these changes in the absence of emission standards for several likely reasons. Since fuel costs are not a significant portion of the overall price of ownership, customers may not place a high value on fuel economy compared to initial cost and engine simplicity. Especially in the case of snowmobiles and off-road motorcycles, manufacturers have built a customer base over many years using 2-stroke technology; ATVs which are dominantly 4-stroke are relatively new to the recreational vehicle market.. The engines are relatively simple and the production costs are relatively low because the manufacturers have been building the engines for many years. To capture the fuel economy benefits, manufacturers would have to invest substantially in R&D and more complex powerplants in the face of uncertainty with regard to market acceptance of the new product. Such a move could also lower profits per vehicle. Considering all these factors, manufacturers have historically chosen to focus improvements in other areas such as increasing horsepower and overall vehicle design.

[ee] Based on publicly available product information for the large manufacturers, we estimated 32 engine lines for snowmobiles, 43 lines for ATVs, and 42 lines for off-highway motorcycles for the 2001 model year.

However, manufacturers are now introducing 4-strokes and direct injection 2-stroke engines into the snowmobile market. For model year 2003, all manufacturers will have at least one 4-stroke snowmobile model available and one manufacturer is introducing direct injection 2-stroke technology. This may mean that manufacturers are adjusting their perspectives on potential marketplace acceptance of advanced technologies.

5.2.3.1.1 Snowmobiles

Phase 1

Snowmobiles are currently almost exclusively powered by carbureted 2-stroke engines. However, as noted above, manufacturers are beginning to introduce 4-strokes and 2-stroke direct fuel injection. Manufacturers have also provided comment that they plan to rely more heavily on these technologies to meet Phase 1 standards than originally thought prior to proposal. For these reasons, we have adjusted our projected baseline technology mix as well as our projected technology mix for the Phase 1 standards for purposes of the cost analysis. Based on discussions with manufacturers, we believe that up to 10 percent of production will be 4-stroke and 10 percent will be direct fuel injection for Phase 1. We believe manufacturers will be ramping up the introduction of these technologies in order to obtain experience with them prior to the start of the program. These technologies will provide surplus emissions reductions which will allow the manufacturers to use lesser technologies on other models under the averaging program.

For cost purposes, we are projecting that 4-stroke engines are likely to be equipped with electronic fuel injection systems to optimize emissions and overall performance of these engines. Therefore we are including electronic fuel injection costs for 4-strokes. Tables 5.2.3-1 through 5.2.3-4 provide costs for direct injection systems (both air assisted direct injection and pump assisted direct injection) and for converting from a 2-stroke to 4-stroke engine with electronic fuel injection.

We have estimated the incremental cost of going from carbureted 2-stroke to direct injection to range from $262 to $342 per engine and conversion to 4-stroke to be about $454 to $770. Electronic fuel injection for snowmobiles is estimated to incrementally cost $174 to $119. Note that the overall consumer costs for these advanced technologies are substantially lower after the fuel economy improvements are taken into account. Estimates of the fuel savings are provided below. For 4-stroke snowmobiles, where possible, we have examined available price information on manufacturer web sites for the various 4-stroke models and comparable 2-stroke models and found price differences to be similar to our cost estimates in most cases. We did not receive detailed public comments on our cost estimates for the various snowmobile technologies.

Table 5.2.3-1: Air Assisted Direct Injection System Costs for Snowmobiles

	< 500 cc		> 500cc	
	Baseline	Modified	Baseline	Modified
Hardware Costs				
Carburetor	$60		$60	
Number Required	2		3	
Fuel Metering Solenoid (each)		$15		$15
Number Required		2		3
Air Pump		$25		$25
Air Pump Gear		$5		$5
Air Pressure Regulator		$5		$5
Throttle Body/Position Sensor		$35		$35
Intake Manifold		$30		$30
Electric Fuel Pump	$5	$5	$5	$5
Fuel Pressure Regulator		$3		$3
ECM		$140		$140
Air Intake Temperature Sensor		$5		$5
Manifold Air Pressure Sensor		$11		$11
Injection Timing Sensor/Timing Wheel		$10		$10
Wiring/Related Hardware		$20		$20
Hardware Cost to Manufacturer	$125	$324	$185	$339
Labor @ $28 per hour	$1	$14	$2	$21
Labor overhead @ 40%	$1	$6	$1	$8
OEM mark-up @ 29%	$37	$100	$55	$107
Royalty @ 3%		$10		$10
Warranty Mark-up @ 5%		$10		$8
Total Component Costs	**$164**	**$464**	**$243**	**$493**
Fixed Cost to Manufacturer				
R&D Costs	$0	$178,500	$0	$178,500
Tooling Costs	$0	$25,000	$0	$25,000
Units/yr.	4,400	4,400	4,400	4,400
Years to recover	5	5	5	5
Fixed cost/unit	**$0**	**$13**	**$0**	**$13**
Total Costs	**$164**	**$476**	**$243**	**$505**
Incremental Total Cost		**$312**		**$263**

Table 5.2.3-2: Pump-Assisted Direct Fuel Injection System Costs for Snowmobiles

	< 500cc		> 500cc	
	Baseline	**Modified**	**Baseline**	**Modified**
Hardware Costs				
Carburetor	$60		$60	
Number Required	2		3	
Nozzle/Accumulator (each)		$33		$33
Number Required		2		3
High-Pressure Cam Fuel Pump		$20		$25
Cam Pump Gear		$5		$5
Throttle Body/Position Sensor		$35		$35
Intake Manifold		$30		$30
Fuel Transfer Pump	$5	$5	$5	$5
ECM		$140		$140
Air Intake Temperature Sensor		$5		$5
Manifold Air Pressure Sensor		$11		$11
Injection Timing Sensor/Timing Wheel		$10		$10
Wiring/Related Hardware		$20		$20
Hardware Cost to Manufacturer	$125	$347	$185	$385
Labor @ $28 per hour	$1	$14	$2	$21
Labor overhead @ 40%	$1	$6	$1	$8
OEM mark-up @ 29%	$37	$106	$55	$120
Royalty @ 3%		$10		$12
Warranty Mark-up @ 5%		$11		$10
Total Component Costs	**$164**	**$494**	**$243**	**$556**
Fixed Cost to Manufacturer				
R&D Costs	$0	$178,500	$0	$178,500
Tooling Costs	$0	$25,000	$0	$25,000
Units/yr.	4,400	4,400	4,400	4,400
Years to recover	5	5	5	5
Fixed cost/unit	**$0**	**$13**	**$0**	**$13**
Total Costs	**$164**	**$506**	**$243**	**$568**
Incremental Total Cost		**$343**		**$327**

Table 5.2.3-3: Two-Stroke to Four Stroke Conversion Costs for Snowmobiles

	< 500 cc		> 500 cc	
	2-Stroke	**4-Stroke**	**2-Stroke**	**4-Stroke**
Engine	$400	$700	$650	$1,170
Clutch	$50	$75	$80	$120
Labor @ $28 per hour	$14	$21	$14	$21
Labor overhead @ 40%	$6	$8	$6	$8
Markup @ 29%	$136	$233	$217	$383
Warranty Mark up @ 5%		$16		$28
Total Component Costs	**$606**	**$1,053**	**$967**	**$1,730**
Fixed Cost to Manufacturer				
R&D Costs	$0	$94,416	$0	$94,416
Tooling Costs	$0	$20,000	$0	$20,000
Units/yr.	4,400	4,400	4,400	4,400
Years to recover	5	5	5	5
Fixed cost/unit	**$0**	**$7**	**$0**	**$7**
Total Costs	**$606**	**$1,060**	**$967**	**$1,737**
Incremental Total Cost		**$455**		**$770**

Table 5.2.3-4: Electronic Fuel Injection Costs for Snowmobiles

Fuel Injection Costs	400cc		700cc	
	Baseline	Modified	Baseline	Modified
Hardware Costs				
Carburetor	$60		$60	
Number Required	2		3	
Injectors (each)		$12		$12
Number Required		2		3
Pressure Regulator		$10		$10
Intake Manifold		$30		$35
Throttle Body/Position Sensor		$35		$35
Fuel Pump	$5	$20	$5	$20
ECM		$100		$100
Air Intake Temperature Sensor		$5		$5
Manifold Air Pressure Sensor		$10		$10
Injection Timing Sensor		$5		$5
Wiring/Related Hardware		$10		$10
Hardware Cost to Manufacturer	**$125**	**$249**	**$185**	**$266**
Labor @ $28 per hour	$1	$4	$2	$6
Labor Overhead @ 40%	$1	$2	$1	$3
Manufacturer Mark-up @ 29%	$37	$72	$54	$77
Warranty Mark-up[a] @ 5%		$6		$4
Total Component Costs	**$164**	**$333**	**$242**	**$356**
Fixed Cost to Manufacturer				
R&D Costs	$0	$69,417	$0	$69,417
Tooling Costs	$0	$10,000	$0	$10,000
Units/yr.	4,400	4,400	4,400	4,400
Years to recover	5	5	5	5
Fixed cost/unit	**$0**	**$5**	**$0**	**$5**
Total Costs ($)	**$164**	**$338**	**$242**	**$361**
Incremental Total Cost ($)		**$175**		**$119**

In addition to the advanced technologies, we are also basing the cost analysis for Phase 1 standards on some use of engine modifications, carburetor improvements, and recalibration. We are projecting lower usage of this approach compared to the proposal (60% compared to 100%) based on the comments we received concerning the use of advanced technology to meet Phase 1 standards. Manufacturers are likely to be able to reduce emissions for some models by leaning out the air/fuel mixture, improving carburetors for better fuel control and less production variation, and modifying the engine to withstand higher temperatures and potential misfire episodes attributed to enleanment. Engine modifications are also likely to be made to improve air/fuel mixing and combustion. The cost estimates for engine modifications and carburetor improvements are provided in Tables 5.2.3-5 and 5.2.3-6. Recalibration work is included as part of the R&D for the technologies. The incremental cost per unit for engine modifications is estimated to be $18 to $25, with modifications to the carburetor estimated to cost an additional $18 to $24 per engine.

Table 5.2.3-5: Snowmobile Engine Modification Costs for Two-Stroke Engines

	< 500 cc		> 500 cc	
	Baseline	Modified	Baseline	Modified
Hardware Costs				
Improved Pistons	$10	$12	$12	$15
Number Required	2	2	3	3
Hardware Cost to Manufacturer	$20	$24	$36	$45
Labor @ $28 per hour	$6	$6	$8	$8
Labor Overhead @ 40%	$2	$2	$3	$3
Manufacturer Mark-up @ 29%	$6	$7	$10	$13
Warranty Mark-up @ 5%		$0		$0
Total Component Costs	$34	$39	$57	$69
Fixed Cost to Manufacturer				
R&D Costs per line	$0	$178,500	$0	$178,500
Tooling Costs	$0	$25,000	$0	$25,000
Units/yr.	4,400	4,400	4,400	4,400
Years to recover	5	5	5	5
Fixed cost/unit	$0	$13	$0	$13
Total Costs	$34	$51	$57	$81
Incremental Total Cost		$18		$25

Table 5.2.3-6: Modified Carburetor Costs for Snowmobiles

	< 500 cc		> 500 cc	
	Baseline	Modified	Baseline	Modified
Hardware Costs				
Carburetor	$60	$65	$60	$65
Number Required	2	2	3	3
Hardware Cost to Manufacturer	$120	$130	$180	$195
Labor @ $28 per hour	$1	$1	$2	$2
Labor Overhead @ 40%	$1	$1	$1	$1
Manufacturer Mark-up @ 29%	$35	$38	$53	$57
Warranty Mark-up @ 5%		$1		$1
Total Component Costs	**$157**	**$171**	**$236**	**$256**
Fixed Cost to Manufacturer				
R&D Costs per line	$0	$61,875	$0	$61,875
Tooling Costs	$0	$5,000	$0	$5,000
Units/yr.	4,400	4,400	4,400	4,400
Years to recover	5	5	5	5
Fixed cost/unit	**$0**	**$4**	**$0**	**$4**
Total Costs	**$157**	**$175**	**$236**	**$260**
Incremental Total Cost		**$18**		**$24**

Phase 2 and Phase 3

We have based the cost analysis for the Phase 2 and Phase 3 standards primarily on the expanded use of direct fuel injection 2-stroke engines and 4-stroke engines. We expect that by the 2010 time frame these two technologies will be fully developed and able to be used on a larger fraction of the fleet. Our projections that these later Phases will be met primarily through the expanded use of these technologies is consistent with our discussions with manufacturers. This chapter provides a cost analysis for the primary Phase 2 program which calls for a 50 percent reduction from baseline levels for both HC and a 30 percent reduction for CO emissions in 2010. The Phase 3 standard begins in 2012 and requires a further reduction in CO from 30 percent to 50 percent. Manufacturers have some flexibility in meeting the Phase 3 standards which allows them to meet less stringent CO requirements if additional HC reductions are achieved. We would expect the same technologies to be used to meet these all of these programs but in somewhat different combinations. For example, some manufacturers may rely on 4-stroke technology more so than direct injection 2-stroke technology. This is discussed in detail in Chapter 4. With averaging, manufacturers, will optimize their technology paths for each phase of standards and each manufacturer will have somewhat different mixes of technology.

For Phase 2 and Phase 3, we are projecting that 50 and 70 percent of models, respectively, will be equipped with either direct injection 2-stroke or 4-stroke engines. We anticipate that remaining models will consist of 2-stroke technologies with some further optimization. One additional technology that may be used is pulse air. We are projecting the use of pulse air systems with recalibration on a portion of the snowmobile engines that are not equipped with advanced technology systems. Pulse air provides a small incremental emission reduction for these engines and would help manufacturers meet the Phase 2 and Phase 3 average HC and CO standards. As shown in Table 5.2.3-7, we have estimated pulse air to cost about $40. Catalysts are also a potential option for snowmobiles but would entail a significant R&D effort and may not be available for snowmobile applications in the 2010 time frame. However, we believe manufacturers are more likely to focus on developing the advanced technologies noted above, which provide the consumer with benefits in addition to lower emissions. Therefore, we have not included catalyst costs in our cost estimates.

Table 5.2.3-7: Calibration/Pulse-Air Costs for Snowmobiles

	Baseline	**Modified**
Hardware Costs		
Pulse Air Valve		$18
Labor @ $28 per hour		$1
Labor overhead @ 40%		$0
Markup @ 29%		$5
Warranty Mark up @ 5%		$0
Total Component Costs	**$0**	**$25**
Fixed Cost to Manufacturer		
R&D Costs		$54,750
Tooling Costs		$200,000
Units/yr.		4,400
Years to recover		5
Fixed cost/unit		**$15**
Total Costs	**$0**	**$40**
Incremental Total Cost		**$40**

5.2.3.1.2 All-terrain Vehicles (ATVs)

ATVs are equipped primarily with carbureted 4-strokes, with 2-stroke engines used mostly in small displacement and sport models. We expect manufacturers to take several steps in response to the standards and test cycle requirements. Beginning in 2006, we expect most manufacturers will take some advantage of the transitional interim test procedures and standards offered from 2006-2008 but will need to phase out the use of 2-stroke engines. In addition, for the 4-stroke ATVs, we are also projecting that as manufacturers transition to the chassis test cycle, recalibration will be needed and that pulse air systems will be used on about 50 percent of the models to ensure that the fleet meets the standards on average. Pulse air systems are currently used on a few ATV and off-highway motorcycles models to meet California standards. We do not believe that the level of the standards will require the use of pulse air beyond 50 percent, given that only a few models in California are currently equipped with the technology. Using pulse air may give the manufacturer more flexibility in calibrating for performance on some models. Technological feasibility is discussed in Chapter 4.

We are basing our technology projection on what manufacturers have done to meet the California emissions standards. We believe this to be the most likely technology path for manufacturers, because 4-strokes are accepted in the market and provide consumers with fuel economy and reliability benefits. Beyond using 4-stroke engines, we expect manufacturers to undertake an R&D effort to recalibrate models and select and optimize pulse air systems. Some recalibration is likely, due to the change in test procedures. We received comments that we underestimated the amount of R&D necessary for ATVs and, upon evaluation, have adjusted the estimates upwards. We continue to believe manufacturers will approach this effort in an orderly manner and we would expect them to focus R&D on a first engine line and then apply what they learn to subsequent lines.[ff] Table 5.2.3-8 provides the estimated R&D for ATVs. We believe the increased level of R&D shown below is substantial considering the technological difficulty of the final standards. We believe the estimated amounts also are sufficient because manufacturers have already invested in R&D and technology to meet the California program which contains standards that are similar in stringency.

Table 5.2.3-8: R&D Cost Estimate for ATVs

	< 200 cc	**> 200 cc**
Base R&D Costs for 1st engine line	$724,000	$724,000
Engine lines per manufacturer	8	8
Base R&D per line	$90,500	$90,500
Individual Engine Line R&D	$238,000	$238,000
Total R&D per line	328,500	$328,500
Units/yr.	5,600	20,000
Years to recover	5	5
R&D Fixed cost/unit	**$16.40**	**$4.59**

Tables 5.2.3-9 and 5.2.3-10 provide cost estimates for the ATV technologies discussed above. We estimate the incremental cost per unit of replacing a 2-stroke engine with a 4-stroke engine to be about $219 to $349, depending on engine size. Costs for a mechanical pulse air system is estimated to be about $27 to $33 per unit. As shown in the tables below, fixed costs

[ff] We have estimated a base R&D effort of 12 months for the first engine line and 6 additional months for subsequent lines and have used the costing methodology provided in the Arthur D. Little - Acurex cost report to calculate the increased R&D cost.

for larger displacement models are spread over a significantly larger annual unit sales volume to account for the relatively high average number of unit sales per engine line for these products.

Table 5.2.3-9: Two-Stroke to Four Stroke Conversion Costs for ATVs

	< 200 cc		> 200 cc	
	2-Stroke	**4-Stroke**	**2-Stroke**	**4 Stroke**
Hardware Costs				
Engine	$400	$550	$500	$750
Labor @ $28 per hour	$14	$21	$14	$21
Labor overhead @ 40%	$6	$8	$6	$8
Markup @ 29%	$122	$168	$151	$226
Warranty Mark up @ 5%		$8		$13
Total Component Costs	**$542**	**$755**	**$671**	**$1,018**
Fixed Cost to Manufacturer				
R&D Costs	$0	$94,416	$0	$94,416
Tooling Costs	$0	$15,000	$0	$18,000
Units/yr.	5,6200	5,600	20,000	20,000
Years to recover	5	5	5	5
Fixed cost/unit	**$0**	**$5**	**$0**	**$2**
Total Costs	**$541**	**$760**	**$670**	**$1,019**
Incremental Total Cost		**$219**		**$349**

Table 5.2.3-10: Pulse-Air Costs for Four-Stroke ATVs

	≤ 200 cc		> 200 cc	
	Baseline	**Modified**	**Baseline**	**Modified**
Hardware Costs				
Pulse Air Valve		$18		$18
Labor @ $28 per hour		$1		$1
Labor overhead @ 40%		$0		$0
Markup @ 29%		$5		$5
Warranty Mark up @ 5%		$0		$0
Total Component Costs	**$0**	**$25**	**$0**	**$25**
Fixed Cost to Manufacturer				
Tooling Costs		$159,091		$159,091
Units/yr.		5,600		20,000
Years to recover		5		5
Fixed cost/unit		**$7**		**$2**
Total Costs	**$0**	**$33**	**$0**	**$27**
Incremental Total Cost		**$33**		**$27**

5.2.3.1.3 Off-highway Motorcycles

Currently, off-highway motorcycles are about 65 percent 2-stroke, with many of the 2-stroke engines used in competition and youth models. As with ATVs, we expect that manufacturers will meet standards primarily by using 4-stroke engines. Manufacturers may also use pulse air systems and recalibration on a relatively small fraction of their models to ensure their overall fleet meets the standards. We have estimated their use for off-highway motorcycles at about 25 percent for purposes of the cost analysis. The R&D efforts will likely be lower for off-highway motorcycles than for ATVs because the level of the standard is less stringent and there is no change in the test procedure from what is now required in California. We do not believe the standards will require pulse air technology in more than 25 percent of models, given that only a few models in California are currently equipped with this technology. As discussed in 5.2.3.4 below, vehicles used solely for competition are exempt from standards and we expect some 2-stroke competition models to remain in the market.

Tables 5.2.3-11 and 5.2.3-12 provide cost estimates for off-highway motorcycle technologies for three engine displacement ranges. We estimate the incremental cost per unit of replacing a 2-stroke engine with a 4-stroke engine to be about $219 to $353, depending on engine size. Costs for a mechanical pulse air valve system and recalibration is estimated to be about $39 per unit.

Table 5.2.3-11: Two-Stroke to Four Stroke Conversion Costs for Off-highway Motorcycles

	< 125 cc		125cc < 250 cc		≥ 250cc	
	2-Stroke	**4-Stroke**	**2-Stroke**	**4-Stroke**	**2-Stroke**	**4-Stroke**
Hardware Costs						
Engine	$400	$550	$450	$650	$500	$750
Labor @ $28 per hour	$14	$21	$14	$21	$14	$21
Labor overhead @ 40%	$6	$8	$6	$8	$6	$8
Markup @ 29%	$122	$168	$136	$197	$151	$226
Warranty Mark up @ 5%		$8		$10		$13
Total Component Costs	**$542**	**$755**	**$606**	**$886**	**$671**	**$1,018**
Fixed Cost to Manufacturer						
R&D Costs	$0	$94,416	$0	$94,416	$0	$94,416
Tooling Costs	$0	$15,000	$0	$15,000	$0	$15,000
Units/yr.	6,000	6,000	6,000	6,000	6,000	6,000
Years to recover	5	5	5	5	5	5
Fixed cost/unit	**$0**	**$5**	**$0**	**$5**	**$0**	**$5**
Total Costs	**$542**	**$760**	**$606**	**$891**	**$670**	**$1,023**
Incremental Total Cost		**$219**		**$286**		**$353**

Table 5.2.3-12: Four-stroke Calibration/Pulse-Air Costs for Off-highway Motorcycles

	< 125 cc		**125 < 250 cc**		**≥ 250cc**	
	Baseline	**Modified**	**Baseline**	**Modified**	**Baseline**	**Modified**
Hardware Costs						
Pulse Air Valve		$18		$18		$18
Labor @ $28 per hour		$1		$1		$1
Labor overhead @ 40%		$0		$0		$0
Markup @ 29%		$5		$5		$5
Warranty Mark up @ 5%		$1		$1		$1
Total Component Costs	**$0**	**$25**	**$0**	**$25**	**$0**	**$25**
Fixed Cost to Manufacturer						
R&D Costs		$54,750		$54,750		$54,750
Tooling Costs		$250,000		$250,000		$250,000
Units/yr.		6,000		6,000		6,000
Years to recover		5		5		5
Fixed cost/unit		**$14**		**$14**		**$14**
Total Costs ($)	**$0**	**$39**	**$0**	**$39**	**$0**	**$39**
Incremental Total Cost ($)		**$39**		**$39**		**$39**

5.2.3.1.4 Crankcase Controls

The proposal included a requirement for crankcase emission controls for recreational vehicles. Crankcase controls have been required on passenger cars for more than 30 years, and it is normally a simple process of routing crankcase exhaust emissions to the engine intake to be burned as part of normal engine operation. Most current 4-stroke recreational vehicle engines use positive crankcase ventilation systems today; crankcase emissions are not significant in current 2-stroke engines. For those converting to 4-stroke in the future, crankcase controls will be required at a cost of about $3 per engine. These are included in the 2-stroke to 4-stroke conversion and replacement costs.

5.2.3.1.5 Permeation Control from Recreational Vehicles

As discussed in earlier chapters, we believe that there are several technologies that could be used to meet the permeation emission standards. Table 5.2.3-13 presents our best estimates of the costs of applying various evaporative emission control technologies to recreational vehicles using the average fuel tank sizes and hose lengths discussed in Chapter 6.

The cost for including low permeation barrier platelets in blow-molded fuel tanks (generally known as Selar®) is based on increased material costs. No changes should be necessary to the blow-molding equipment. We used 10 percent EVOH which is about $3 per pound and 90 percent HDPE which is about $0.50 per pound. This equates to a price increase of about $0.30 per pound. Depending on the shape of the fuel tank and the wall thickness, recreational vehicle fuel tanks weigh about 1-1.3 pounds per gallon of capacity. Costs for multi-layer fuel tanks with continuous barriers are not included, but would be expected to be higher because two additional injection screws would be necessary for the barrier and adhesion layers. Another option would be to mold the entire fuel tank of a low permeation material such as nylon, an acetal copolymer, or a thermoplastic polyester. These materials have list prices of about $2.00 per pound; therefore, the cost of using these alternative materials would be about 7 times higher than presented below for barrier platelets with 10% EVOH.

Surface treatment costs are based on price quotes from a companies that specialize in this fluorination[14] and sulfonation.[15] The fluorination costs are a function of the geometry of the fuel tanks because they are based on how many fuel tanks can be fit in a treatment chamber. The price sheet referenced for our fluorination prices assumes rectangular shaped containers. For irregular shaped fuel tanks, the costs would be higher because they would have to be fit into baskets with volumes larger than the volume of the fuel tanks. Therefore, we consider a void space equal to about 25 percent of the volume of the fuel tank. For sulfonation, the shape of the fuel tanks is less of an issue because the treatment process is limited only by the spacing on the production line which is roughly the same for the range of fuel tank sizes used in recreational vehicles. These prices do not include the cost of transporting the tanks; we estimated that shipping, handling and overhead costs would be an additional $0.22 to $0.81 per fuel tank depending on tank size.[16]

Barrier fuel hose incremental costs estimates are based on costs of existing products used in marine and automotive applications.[17,18,19] We estimate that the cost increment compared to R7 hose used in most recreational applications today is about $0.60 per foot. Some manufacturers have commented that they do not use hose clamps today, but would need them if they use barrier hose. Other manufacturers already use hose clamps, but may need to upgrade them in some applications. To be conservative, we consider the cost of adding hose clamps to all applications. These hose clamps cost about $0.20 each.[20] For ATVs and OHMCs, we include the costs of two hose clamps for each vehicle (one for each end of the hose). Snowmobiles can require 4 to 8 hose clamps depending on the fuel pump configuration, number of carburetors, and if a fuel return line is included. We include the cost of 6 hose clamps for snowmobiles in this analysis.

Table 5.2.3-13: Permeation Control Technologies and Incremental Costs

Technology		*Snowmobiles* *11 gallon tank* *3.5 ft. hose*	*ATVs*** *4 gallon tank* *1 ft. hose*	*OHMCs* *3 gallon tank* *1.5 ft. hose*
barrier platelets (10% EVOH)		$3.30	$1.50	$1.20
sulfonation	treatment*	$1.50	$1.20	$1.20
	shipping/handling	$0.81	$0.30	$0.22
fluorination	treatment*	$8.39	$3.23	$2.42
	shipping/handling	$0.81	$0.30	$0.22
1/4" I.D. hose	barrier fuel hose*	$2.71	$0.77	$1.16
	hose clamps*	$1.55	$0.52	$0.52

* includes a 29% markup for overhead and profit
** includes utility vehicles

Manufacturers, with high enough production volumes, could reduce the costs of sulfonating fuel tanks by constructing an in-house treatment facility. The cost of a sulfonation production line facility that could treat 150-500 thousand fuel tanks per year would be approximately $800,000.[21] This facility, which is designed to last at least 10 years, is made up of a SO_3 generator, a scrubber to clean up used gas, a conveyor belt, and injection systems for the SO_3 gas and for the neutralizing agent (ammonia solution). The manufacturer of this equipment estimates that the operating costs, which includes electricity and chemicals, would be about 3 cents per tank. Based on a production capacity of 150,000 units per year, and a 10 year life, the average sulfonation cost per fuel tank would be about $0.60. These costs would be lower for higher production volumes. In addition, if a manufacturer were to sulfonate their fuel tanks in-house, they would not need to pay shipping and handling costs.

To determine the total costs per recreational vehicle we use the scenario that all manufacturers use sulfonation to reduce permeation from their fuel tanks and use barrier fuel hose. For this analysis, we consider the cost of shipping fuel tanks to an outside vendor for treatment rather than using the lower cost of in-house sulfonation. For competition off-highway motorcycles, which make up about 29 percent of OHMC sales, we assume that no low permeation technology would be used. We estimate the total per vehicle costs to be $6.56 for snowmobiles, $2.79 for ATVs, and $3.10 for non-competition OHMCs. Weighting a cost of $0 for competition OHMCs, we get an average cost of $2.14 per off-highway motorcycle. These costs do not include the fuel savings associated with a reduction permeation which is discussed below in section 5.2.3.2.3.

As a sensitivity analysis, we estimated what the costs would be if the fuel tank permeation control technology applied by manufacturers were equally distributed by barrier platelets, sulfonation, and fluorination. Not considering fuel costs, the estimated fuel tank costs, under this scenario, would be $4.93 for snowmobiles, $2.18 for ATVs, and $1.75 for non-competition OHMCs. This represents about a 20-100% increase in the cost estimates for fuel tanks (no change in fuel hose costs). However, we believe that manufacturers are likely to use sulfonation to meet the fuel tank permeation standards because it appears to be the most cost effective strategy in most cases. Although barrier platelets and fluorination could likely be applied earlier, we believe that we are providing adequate lead time for manufacturers to incorporate sulfonation into their commercial processes.

5.2.3.2 Operating Cost Savings

5.2.3.2.1 Snowmobiles

Both direct injection and conversion from two-stroke to 4-stroke yield substantial fuel economy benefits. Typical 2-stroke engines have relatively poor fuel economy performance because a portion of the combustion mixture passes through the engines unburned. Because 4-stroke and direct injection 2-stroke engine designs essentially do not allow this to occur, they provide better fuel economy as well as substantially lower HC emissions. We have estimated fuel savings based on a 25 percent reduction in fuel consumption, based on typical performance of these technologies. Lifetime fuel costs are provided in Table 5.2.3-14.[22, 23]

Table 5.2.3-14: Fuel Cost for Snowmobiles

Engine	Baseline 2-Stroke		Advanced Technology Engines (25% savings)	
	small	large	small	large
Engine power	45	100	45	100
Load Factor	0.34	0.34	0.34	0.34
Annual Operating Hours, hr/yr	57	57	57	57
Lifetime, yr	12	12	12	12
BSFC, lb/bhp-hr	1.66	1.25	1.66	1.25
Fuel Density (lbs/gal)	6.17	6.17	6.17	6.17
Fuel Cost ($/gal)*	$1.10	$1.10	$1.10	$1.10
Yearly Fuel Consumption (gal/yr)	235	521	176	391
Yearly Fuel Cost ($/yr)	$258	$574	$194	$430
Lifetime Fuel Cost (NPV)	**$2,050**	**$4,556**	**$1,537**	**$3,417**

* Excluding taxes

5.2.3.2.2 ATVs and Off-highway Motorcycles

Conversion from 2-stroke to 4-stroke engines yields a fuel economy improvement for ATVs and off-highway motorcycles as well. Tables 5.2.3-15 and 5.2.3-16 provide estimates of fuel consumption for both 2-stroke and 4-stroke engines. We have estimated that switching from a 2-stroke to a 4-stroke engine reduces fuel consumption by about 25 percent. Lifetime fuel savings for ATVs resulting from switching from a 2-stroke to a 4-stroke engine is estimated to be $124. For off-highway motorcycles, the projected lifetime fuel savings is $140.

Table 5.2.3-15: Fuel Cost for ATVs

Engine	2-Stroke	4-Stroke
Annual Miles	1,570	1,570
Lifetime, yr	13	13
BSFC, lb/mile	0.213	0.160
Fuel Density (lbs/gal)	6.17	6.17
Fuel Cost ($/gal)*	$1.10	$1.10
Yearly Fuel Consumption (gal/yr)	54	41
Yearly Fuel Cost ($/yr)	$60	$45
Lifetime Fuel Cost (NPV)	**$498**	**$374**

* Excluding taxes

Table 5.2.3-16: Fuel Cost Savings for Off-highway Motorcycles

Engine	2-Stroke	4-Stroke
Annual Miles	1,600	1,600
Lifetime, yr	12	12
BSFC, lb/mile	0.268	0.201
Fuel Density (lbs/gal)	6.17	6.17
Fuel Cost ($/gal)*	$1.10	$1.10
Yearly Fuel Consumption (gal/yr)	68	52
Yearly Fuel Cost ($/yr)	$75	$57
Lifetime Fuel Cost (NPV)	**$594**	**$454**

* Excluding taxes

5.2.3.2.3 Permeation Control Fuel Savings

Evaporative emissions are essentially fuel that is lost to the atmosphere. Over a the lifetime of a typical recreational vehicle, this can result in a significant loss in fuel. The anticipated reduction in evaporative emissions due to the permeation standards will result in significant fuel savings. Table 5.2.3-17 presents the value of the fuel savings for control of permeation emissions. These numbers are calculated using an estimated fuel cost of $1.10 per gallon and fuel density of 6 lbs/gallon (for lighter hydrocarbons which evaporate first). The figures in Table 5.2.3-17 are based on the per vehicle emissions described in Chapter 6.

Table 5.2.3-17: Fuel Savings Per Vehicle Due to the Proposed Standards

Average Parameters	Snowmobiles	ATVs	OHMCs
Evaporative HC reduced [tons/life]	0.0396	0.0221	0.0177
Fuel savings [gallons/life]	13	7	6
Undiscounted savings [$/life @$1.10/gal]	$14	$8	$6
Lifetime fuel savings (NPV, 7%)	$11	$6	$5

5.2.3.3 Compliance Costs

We estimate ATV and off-highway motorcycle chassis-based certification to cost about $25,000 per engine line, including $10,000 for engineering and clerical work and $15,000 for durability and certification testing. For snowmobile engine-based certification, we estimate costs to be about $30,000, recognizing that engine testing is somewhat more expensive than vehicle testing due to the time needed to set up the engine on the test stand. As with other fixed costs, we amortized the cost over 5 years of engine sales to calculate per unit certification costs shown in Table 5.2.3-18. The actual certification costs for ATVs and off-highway motorcycles are likely to be lower than those shown in the table above because manufacturers are likely to use certification data generated for the California program.

Table 5.2.3-18: Estimated Per Unit Certification Costs

	Snowmobiles	ATVs		Off-highway Motorcycles
units/year/family	4,400	5,600	20,000	6,000
certification costs	$1.78	$1.17	$0.21	$1.09

We have estimated that manufacturers must test about 0.2 percent of their production to meet production-line testing requirements. Using per test costs of $2,500 for vehicle testing and $5,000 per test for engine testing, we estimate a per unit cost for production line testing of $5 for off-road motorcycles and ATVs and $10 for snowmobiles.

In general, we expect manufacturers to use existing test facilities. For manufacturers with insufficient chassis testing capabilities for ATVs, we expect them to carry over engine-based certifications from the California program during the transition period, but to phase-in chassis-based certification during the transition time frame. Because the option of engine-based testing is available for only three years, manufacturers will need to do chassis testing of ATVs by 2009. We have therefore estimated the cost of new chassis testing facilities to be included in the cost of the standards. The costs are based on an estimate provided by one manufacturer that a full test cell would cost $2 million to build. We have estimated that on average manufacturers will need two such facilities to conduct testing. The costs will vary somewhat among manufacturers depending on the state of their existing facilities and the number of vehicle families that must be certified. However, we believe that this is a generous estimate because some manufacturers will likely be able to upgrade existing test facilities instead of building new facilities.

By estimating $4 million per manufacturer, with 7 manufacturers, and amortizing the costs over 10 years (10 years x 729,000 units), we estimate an average per unit cost of $6.70. We have used 10 years for amortization rather than 5 years because we believe it is more representative for a capital investment that will be used at least that long.

5.2.3.4 Recreational Vehicle Total Costs

The analysis below combines the costs estimated above for various technologies into a total composite or average cost for each vehicle type. The composite analysis weights the costs by projecting the percentage of the use of various technologies, both in the baseline and control scenario, to project industry-wide average per vehicle costs. The technologies and the mix projections are discussed in Chapter 4 and are based largely on discussions with individual manufacturers and in some cases on confidential business information.

A summary of the estimated near-term and long-term per unit average incremental costs and fuel savings for recreational vehicles is provided in Table 5.2.3-19. Long-term costs do not include fixed costs, which are retired, and include cost reductions due to the learning curve.

Table 5.2.3-19: Total Average Per Unit Costs and Fuel Savings

	Snowmobile Phase 1	Snowmobile Phase 2	Snowmobile Phase 3	ATV	Off-highway Motorcycle
near-term costs	$80	$131	$89	$87	$158
long-term costs	$47	$77	$54	$45	$98
fuel savings (NPV)	($67)	($286)	($191)	($29)	($53)

Tables 5.2.3-20 through 5.2.3-24 provide the detailed average, or composite, per unit costs for snowmobiles, ATVs, and off-highway motorcycles. For snowmobiles, where there are three phases of standards, the costs are incremental to the previous standard. The composite costs are based on the estimated distribution of the different engine displacement ranges. We estimated an approximate distribution of sales among the displacement ranges using limited sales data provided by some manufacturers on a confidential basis and production data from Power Systems Research. Incremental costs are shown both for the near-term and long-term. Long term costs reflect the retirement of fixed costs and the affect of the learning curve, described in section 5.1.

Table 5.2.3-20: Estimated Average Costs For Snowmobiles (Phase 1)

		Cost	Lifetime Fuel Savings	Baseline	Phase 1	Incremental Cost	Incremental Fuel Savings
< 500 cc (30%)	engine modifications	$18	$0	0%	60%	$11	$0
	modified carburetor	$18	$0	0%	60%	$11	$0
	direct injection*	$328	($512)	7%	10%	$10	($15)
	electronic fuel injection	$175	$0	12%	15%	$5	$0
	4-stroke engine	$455	($512)	7%	10%	$14	($15)
	permeation control	$7	($11)	0%	100%	$7	($11)
	compliance	$12	--	0%	100%	$12	$0
	total	--	--	--	--	$69	($41)
≥ 500 cc (70%)	engine modifications	$25	$0	0%	60%	$15	$0
	modified carburetor	$24	$0	0%	60%	$14	$0
	direct injection*	$295	($1,139)	7%	10%	$9	($34)
	electronic fuel injection	$119	$0	12%	15%	$4	$0
	4-stroke engine	$770	($1,139)	7%	10%	$23	($34)
	permeation control	$7	($11)	0%	100%	$7	($11)
	compliance	$12	$0	0%	100%	$12	$0
	total	--	--	--	--	$84	($79)
Near Term Composite Incremental Cost		--	--	--	--	**$80**	**($67)**
Long Term Composite Incremental Cost		--	--	--	--	**$47**	**($67)**

Table 5.2.3-21: Estimated Average Costs For Snowmobiles For Phase 2 Incremental to Phase 1

		Cost	Lifetime Fuel Savings	Phase 1	Phase 2	Incremental Cost	Incremental Fuel Savings
< 500 cc (30%)	pulse air/recalibration	$41	$0	0%	30%	$12	$0
	direct injection*	$328	($512)	10%	35%	$82	($128)
	electronic fuel injection	$175	$0	15%	20%	$9	$0
	4-stroke engine	$455	($512)	10%	15%	$23	($26)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$128	($154)
≥ 500 cc (70%)	pulse air/recalibration	$41	$0	0%	30%	$12	$0
	direct injection*	$295	($1,139)	10%	35%	$74	($285)
	electronic fuel injection	$119	$0	15%	20%	$6	$0
	4-stroke engine	$770	($1,139)	10%	15%	$39	($57)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$132	($342)
Near Term Composite Incremental Cost		--	--	--	--	$131	($286)
Long Term Composite Incremental Cost		--	--	--	--	$77	($286)

* Direct injection costs are an average of the air-assisted and pump assisted system costs.

Table 5.2.3-22: Estimated Average Costs For Snowmobiles Phase 3 Incremental to Phase 2

		Cost	Lifetime Fuel Savings	Phase 2	Phase 3	Incremental Cost	Incremental Fuel Savings
< 500 cc (30%)	pulse air/recalibration	$41	$0	30%	30%	$0	$0
	direct injection*	$328	($512)	35%	50%	$49	($77)
	electronic fuel injection	$175	$0	20%	25%	$9	$0
	4-stroke engine	$455	($512)	15%	20%	$23	($26)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$83	($103)
≥ 500 cc (70%)	pulse air/recalibration	$41	$0	30%	30%	$0	$0
	direct injection*	$295	($1,139)	35%	50%	$44	($171)
	electronic fuel injection	$119	$0	20%	25%	$6	$0
	4-stroke engine	$770	($1,139)	15%	20%	$39	($57)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$91	($228)
Near Term Composite Incremental Cost		--	--	--	--	**$89**	**($191)**
Long Term Composite Incremental Cost		--	--	--	--	**$54**	**($191)**

* Direct injection costs are an average of the air-assisted and pump assisted system costs.

Table 5.2.3-23: Estimated Average Costs For ATVs

		Cost	Lifetime Fuel Savings (NPV)	Baseline	Control	Incremental Cost	Incremental Fuel Savings (NPV)
< 200 cc (15%)	4-stroke engine	$219	($124)	8%	100%	$202	($114)
	pulse air	$33	$0	0%	50%	$17	$0
	R&D for exhaust including recalibration	$16	$0	0%	100%	$16	$0
	permeation control	$3	($6)	0%	100%	$3	($6)
	compliance	$13	--	0%	100%	$13	--
	total	--	--	--	--	$251	($119)
> 200 cc (85%)	4-stroke engine	$349	($124)	93%	100%	$24	($9)
	pulse air/recalibration	$27	$0	0%	50%	$14	$0
	R&D for exhaust including recalibration	$5	$0	0%	100%	$5	$0
	permeation control	$3	($6)	0%	100%	$3	($6)
	compliance	$12	--	0%	100%	$12	--
	total	--	--	--	--	$58	($14)
Near Term Composite Incremental Cost		--	--	--	--	**$87**	**($29)**
Long Term Composite Incremental Cost		--	--	--	--	**$45**	**($29)**

Table 5.2.3-24: Estimated Average Costs For Off-highway Motorcycles (Non-competition models only)

		Cost	Lifetime Fuel Savings (NPV)	Baseline	Control	Incremental Cost	Incremental Fuel Savings (NPV)
< 125 cc (37%)	4-stroke engine	$219	($140)	82%	100%	$39	($11)
	pulse air/recalibration	$39	$0	0%	25%	$10	$0
	permeation control	$3	($5)	0%	100%	$3	($5)
	compliance	$7	--	0%	100%	$7	--
	total	--	--	--	--	$59	($16)
125 < 250 cc (21%)	4-stroke engine	$286	($140)	30%	100%	$200	($98)
	pulse air/recalibration	$39	$0	0%	25%	$10	$0
	permeation control	$3	($5)	0%	100%	$3	($5)
	compliance	$7	--	0%	100%	$7	--
	total	--	--	--	--	$220	($103)
≥ 250 cc (42%)	4-stroke engine	$353	($140)	45%	100%	$194	($77)
	pulse air/recalibration	$39	$0	0%	25%	$10	$0
	permeation control	$3	($5)	0%	100%	$3	($5)
	compliance	$7	--	0%	100%	$7	--
	total					$214	($82)
Near Term Composite Incremental Cost		--	--	--	--	**$158**	**($53)**
Long Term Composite Incremental Cost		--	--	--	--	**$98**	**($53)**

The above table for off-highway motorcycles shows the anticipated split between two-stroke and 4-stroke models in the various engine size categories. Currently, off-highway motorcycles are about 63 percent 2-stroke with many of the 2-stroke engines used in competition and youth models. In recent years, more high performance and competition models have been successfully introduced with 4-stroke engines and there appears to be a trend toward increased use of 4-stroke engines. Models used solely for competition are exempt from emission standards. We expect some 2-stroke competition models to continue to be available under this exemption. For purposes of the cost analysis, we have estimated that 29 percent of all off-highway motorcycles will be exempt as competition models and that these models will be equipped with 2-stroke engines. We have based the estimate of exempt models on the our estimate of the current use of 2-strokes in the motocross market. We believe the emissions standards will be achievable for 4-stroke engines, especially with averaging, and that manufacturers would elect to certify all 4-stroke models to market them to the widest possible consumer base.

To account for the competition model exemption in the calculation of average costs, we have adjusted the percentage of 2-stroke engines from the overall baseline percentage of off-highway motorcycle sales using the 29 percent estimate noted above. This adjustment is necessary to determine average costs only for those off-highway motorcycles covered by the program. Table 5.2.3-25 provides our estimate of the baseline percentage of 2-strokes in overall sales and the percentage of the non-competition model sales.

Table 5.2.3-25: Estimated Off-highway Motorcycle Percent 2-stroke Engine Usage

Displacement	Overall Baseline 2-stroke percentage	Baseline 2-stroke percentage Excluding Competition Models
< 125 cc	42%	18%
125 to 249 cc	79%	70%
> 250 cc	68%	55%

5.2.3.5 Recreational Vehicle Aggregate Costs

The above analyses developed incremental per vehicle cost estimates for snowmobiles, ATVs, and off-highway motorcycles. Using these per vehicle costs and projections of future annual sales, we have estimated total aggregate annual costs for the recreational vehicles standards. The aggregate costs are presented on a cash flow basis, with hardware and fixed costs incurred in the year the vehicle is sold and fuel savings occurring as the vehicle is operated over its life. This may understate the time-value of the fixed costs because they are likely to be incurred before the vehicle is sold; however, this has a negligible effect on the results of this analysis. Table 5.2.3-26 presents a summary o f the results of this analysis. As shown in the table, aggregate net costs increase from about $65 million in 2006 to about $129 million in 2010. Net costs are projected then to decline as fuel savings continue to ramp-up as more vehicles meeting the standards are sold and used and fixed costs are amortized. Fuel savings are projected to more than offset the costs of the program starting in 2015.

Table 5.2.3-26
Summary of Annual Aggregate Costs and Fuel Savings (millions of dollars)

	2006	2010	2015	2020	2025
Snowmobiles	$6.58	$37.55	$41.91	$41.56	$41.56
ATVs	$42.46	$62.55	$49.69	$44.81	$44.81
Off-highway Motorcycles	$16.27	$24.24	$21.53	$22.63	$23.79
Permeation control	--	$4.59	$4.72	$4.83	$4.86
Total	$65.31	$128.93	$117.85	$113.83	$115.02
Fuel Savings	($1.60)	($39.90)	($121.70)	($187.00)	($212.60)
Net Costs	$63.71	$89.03	($3.85)	($73.17)	($97.58)

To project annual sales, we started with 2001 sales estimates provided by industry organizations. We then adjusted the numbers and applied sales growth estimates consistent with the modeling performed to estimate total emissions (see Section 6.2.4.1.1). For ATVs, we added 70,000 units to account for sales from companies not included in the industry organization estimates. Sales growth for snowmobiles and off-highway motorcycle sales is projected to be about one percent per year. The off-road motorcycle sales were reduced by 29 percent to account for the exemption of competition models. ATVs are modeled differently because recent sales growth rates have been significantly higher than one percent but are at rates not likely to be sustained indefinitely. We project that ATV sales will continue to grow at a higher rate over the next few years but will level off by 2006. Table 5.2.3-27 provides a summary of the sales estimates used in the aggregate cost analysis.

Table 5.2.3-27: Estimated Annual Recreational Vehicle Sales

	2001	2006	2010	2020
Snowmobiles	140,629	189,497	210,367	240,162
ATVs	880,000	985,754	985,754	985,754
Off-highway motorcycles*	195,250	205,210	213,542	235,883

* Non-competition only

To calculated annual aggregate costs, the sales estimates have been multiplied by the per unit costs. Fuel savings have been calculated using the NONROAD model to calculate the shift in use from 2-stroke to 4-stroke vehicles, and also direct injection 2-strokes for snowmobiles, over time. The model takes into consideration vehicle sales and scrappage rates. The standards phase-in schedule for off-highway motorcycles and ATVs (50/100% in 2006/2007) has also been taken into account. The detailed year-by-year analysis is provided in Chapter 7.

Chapter 5 References

1."Update of EPA's Motor Vehicle Emission Control Equipment Retail Price Equivalent (RPE) Calculation Formula," Jack Faucett Associates, Report No. JACKFAU-85-322-3, September 1985 (Docket A-2000-01, document II-A-54).

2.For further information on learning curves, see Chapter 5 of the Economic Impact, from Regulatory Impact Analysis - Control if Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements, EPA420-R-99-023, December 1999. A copy of this document is included in Air Docket A-2000-01, at Document No. II-A-83. The interested reader should also refer to previous final rules for Tier 2 highway vehicles (65 FR 6698, February 10, 2000), marine diesel engines (64 FR 73300, December 29, 1999), nonroad diesel engines (63 FR 56968, October 23, 1998), and highway diesel engines (62 FR 54694, October 21, 1997).

3."Estimated Economic Impact of New Emission Standards for Heavy-Duty Highway Engines," by Lou Browning, Acurex Environmental Corporation Final Report (FR 97-103), March 31, 1997, Docket A-2000-01, document II-A-51.

4."Incremental Costs for Nonroad Engines: Mechanical to Electronic," Memorandum from Lou Browning, Acurex Environmental, to Alan Stout, EPA, April 1, 1997 (Docket A-2000-01, document II-A-52).

5."Incremental Cost Estimates for Marine Diesel Engine Technology Improvements," Memorandum from Louis Browning and Kassandra Genovesi, Arcadis Geraghty & Miller, to Alan Stout, EPA, September 30, 1998 (Docket A-2000-01, document II-A-53).

6."Large SI Engine Technologies and Costs," by Lou Browning, Arthur D. Little - Acurex Environmental, Final Report, September 2000, Docket A-2000-01, document II-A-15.

7. "Exhaust Controls Available to Reduce Emissions from Nonroad Heavy-Duty Engines," in Clean Air Technology News, Winter 1997, p. 1 (Docket A-98-01; item II-A-02).

8. "It's Not Easy Being Green," Modern Materials Handling, April 2000 (Docket A-2000-01; item II-A-06).

9. Letter from William Platz, Western Propane Gas Association, January 24, 2001 (Docket A-2000-01; item II-D-40).

10. "It's Not Easy Being Green," Modern Materials Handling, April 2000 (Docket A-2000-01; item II-A-06).

11. “Nonroad Recreational Vehicle Technologies and Costs”, Arthur D. Little - Acurex Environmental, Draft Final Report, July 2001 (Docket A-2000-01, document II-A-31)..

12. “Nonroad Recreational Vehicle Technologies and Costs”, Arthur D. Little - Acurex Environmental, Draft Final Report, July 2001 (Docket A-2000-01, document II-A-31).

13. “Nonroad Recreational Vehicle Technologies and Costs”, Arthur D. Little - Acurex Environmental, Draft Final Report, July 2001 (Docket A-2000-01, document II-A-31).

14. “Information on Costs and Effectiveness of Fluorination Received from Fluoroseal,” Memorandum from Mike Samulski to Docket A-2000-1, March 27, 2002, Docket A-2000-01, Document IV-B-03.

15. “Visit to Sulfo Technologies LLC on April 18, 2002,” Memorandum from Mike Samulski, U.S. EPA to Docket A-2000-01, April 22, 2002, Document IV-B-07.

16. “Shipping Costs,” Memorandum from Glenn Passavant, U.S. EPA to Docket A-2000-01, March 27, 2002, Document IV-B-01.

17. Trident Marine Hose, “Retail Price List 2001,” Docket A-2000-01, Document No. IV-A-15.

18. Denbow, R., Browning, L., Coleman, D., “Report Submitted for WA 2-9, Evaluation of the Costs and Capabilities of Vehicle Evaporative Emission Control Technologies,” ICF, ARCADIS Geraghty & Miller, March 22, 1999, Docket A-2000-01, Document No. IV-B-05.

19. “Meeting with Avon on June 27, 2002,” Memorandum from Mike Samulski, U.S. EPA to Docket A-2000-01, August 6, 2002, Docket A-2000-01, Document IV-E-33.

20. Denbow, R., Browning, L., Coleman, D., “Report Submitted for WA 2-9, Evaluation of the Costs and Capabilities of Vehicle Evaporative Emission Control Technologies,” ICF, ARCADIS Geraghty & Miller, March 22, 1999, Docket A-2000-01, Document No. IV-B-05.

21. “Visit to Sulfo Technologies LLC on April 18, 2002,” Memorandum from Mike Samulski, U.S. EPA to Docket A-2000-01, April 22, 2002, Document IV-B-07.

22. Brake-specific fuel consumption (BSFC) based on 4-stroke BSFC estimates provided by Power Systems Research.

23. “Monthly Energy Review”, Calendar year 2000 average Refiner Prices of Petroleum Products to End Users (Cents per gallon, excluding taxes), Energy Information Administration.

Chapter 6: Emissions Inventory

6.1 Methodology

The following chapter presents our analysis of the emission impact of the standards for recreational marine, large spark-ignition equipment, snowmobiles, all-terrain vehicles, and off-highway motorcycles. We first present an overview of the methodology used to generate the emissions inventories, followed by a discussion of the specific information used in generating the inventories for each of the regulated categories of engines as well as the emission inventories. Emissions from a typical piece of equipment are also presented.

6.1.1 Off-highway Exhaust Emissions

We are in the process of developing an emission model that will calculate emissions inventories for most off-highway vehicle categories, including those in this rule. This draft model is called NONROAD. For this effort we use the most recent version of the draft NONROAD model publicly available with some updates that we anticipate will be included in the next draft release. This section gives a brief overview of the calculation methodology used in NONROAD for calculating exhaust emission inventories. Inputs and results specific to each of the off-highway categories in this rule are discussed in more detail later in this chapter. For more detailed information on the draft NONROAD model, see our website at www.epa.gov/otaq/nonrdmdl.htm.

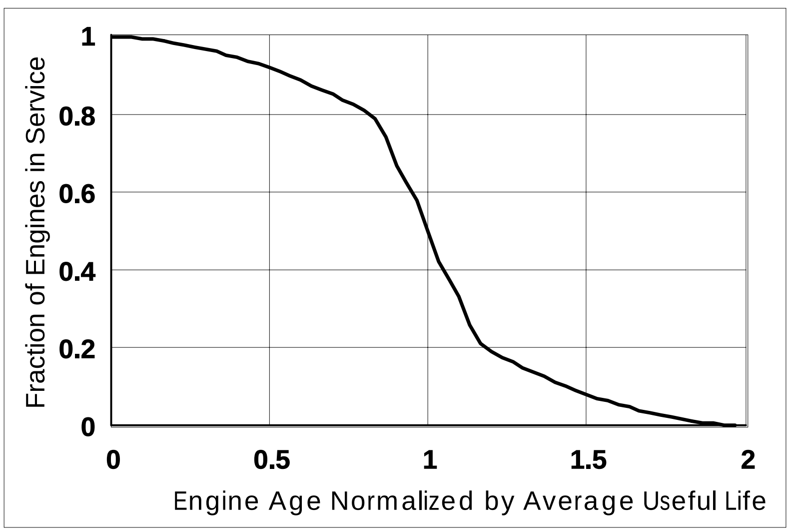
For the inventory calculations in this rule, each class of off-highway engines was divided into power ranges to distinguish between technology or usage differences in each category. Each of the engine applications and power ranges were modeled with distinct annual hours of operation, load factors, and average engine lives. The basic equation for determining the exhaust emissions inventory, for a single year, from off-highway engines is shown below:

$$Emissions = \sum_{ranges} (population \times power \times load \times annual\,use \times emission\,factor) \qquad \textbf{(Eq. 6-1)}$$

This equation sums the total emissions for each of the power ranges for a given calendar year. “Population” refers to the number of engines estimated to be in the U.S. in a given year. “Power” refers to the population-weighted average rated power for a given power range. Two usage factors are included; “load” is the ratio between the average operational power output and the rated power, and “annual use” is the average hours of operation per year. Emission factors are applied on a brake-specific basis (g/kW-hr) and represent the weighted value between levels from baseline and controlled engines operating in a given calendar year. Exhaust emission inventories were calculated for HC, CO, and NOx from all engines and additionally for PM from compression-ignition engines. Although some of the emission standards combine HC and NOx, it is useful to consider the HC and NOx emission impacts separately. (As described throughout this document, the standards for all-terrain vehicles (ATVs) and off-highway motorcycles are based on a chassis test, with the standards in grams per kilometer. For these two categories of equipment, the equation used by the NONROAD model for calculating emissions is similar to Equation 6-1 except that the "load factor" and "power" terms are not included in the calculation, the "annual use" is input on a miles/year basis, and the "emission factors" are entered on a gram per mile basis.)

To be able to determine the mix between baseline and controlled engines, we need to determine the turnover of the fleet. Through the combination of historical population and scrappage rates, historical sales and retirement of engines can be estimated. We use a normalized scrappage rate and fit it to the data for each engine type on average operating life. Figure 6.1.1-1 presents the normalized scrappage curve used in the draft NONROAD model. For further discussion of this scrappage curve, see our report titled "Calculation of Age Distributions -- Growth and Scrappage," (NR-007).

Figure 6.1.1-1: Normalized Scrappage Curve



6.1.2 Off-highway Evaporative Emissions

Evaporative emissions refer to hydrocarbons released into the atmosphere when gasoline, or other volatile fuels, evaporate from a vehicle. For this analysis, we model three types of evaporative emissions:

- <u>permeation</u>: These emissions are due to fuel that works its way through the material used in the fuel system. Permeation is most common through plastic fuel tanks and rubber hoses.

- diurnal: These emissions are due to temperature changes throughout the day. As the day gets warmer, the fuel heats up and begins to evaporate.

- refueling: These emissions are the vapors displaced from the fuel tank when fuel is dispensed into the tank.

We are currently in the process of revising the inputs to the calculations for evaporative emissions in the draft NONROAD model. The analysis for this rule includes the inputs that we anticipate will be used in the draft NONROAD model. The evaporative emission calculations are available in spreadsheet form in the docket.[1]

Because diurnal and refueling emissions are dependent on ambient temperatures and fuel properties which vary through the nation and through the year, we divided the nation into six regions and modeled each region individually for each day of the year. The daily temperatures by region are based on a report which summarizes a survey of dispensed fuel and ambient temperatures in the United States.[2]

6.1.2.1 Permeation Emissions

For our permeation emissions modeling, we used the emission data presented in Chapter 4 to determine the mass of hydrocarbons permeated through plastic fuel tanks and rubber fuel hoses on recreational vehicles. No permeation occurs through metal fuel tanks. Because permeation is very sensitive to temperature, we used Arrhenius' relationship[3] to adjust the emission factors by temperature:

$$P(T) = P_0 \times EXP(-\alpha / T) \qquad \textbf{(Eq. 6-2)}$$

where:

T = absolute temperature
P(T) = permeation rate at T
P_0 and α are constants

We determined the constants by relating the equation to the known properties of materials used in fuel tanks and hoses (presented in Chapter 4). Based on data presented in Chapter 4, permeation increases by about 80 percent with each 10°C increase in temperature for high density polyethylene (HDPE). We do not have similar data for nitrile rubber used in hoses; however, in general, permeation doubles with every 10°C increase in temperature.[4] In addition, we have data on the effect of temperature on permeation through FKM which is a fluoroelastomer commonly used as a permeation barrier in hoses. This data, presented in Chapter 4, supports using the general relationship, in our modeling, of doubling permeation through hoses for every 10°C increase in temperature.

6.1.2.2 Diurnal Emissions

For diurnal emission estimates, we used the Wade equations[5,6,7] to calculate grams of hydrocarbons emitted per day per volume of fuel tank capacity. The Wade equations are well established and are used in both the MOBILE and draft NONROAD models with an adjustment based on empirical data. These calculations are a function of vapor space, fuel vapor pressure, and daily temperature variation and are as follows:

$$\text{Vapor space (ft}^3\text{)} = ((1.15 - \text{tank fill}) \times \text{tank size}) / 7.841 \qquad \textbf{(Eq. 6-3)}$$

where:

tank fill = fuel in tank/fuel tank capacity
tank size = fuel tank capacity in gallons

$$T_1\ (°F) = (T_{max} - T_{min}) \times 0.922 + Tmin \qquad \textbf{(Eq. 6-4)}$$

where:

T_{max} = maximum diurnal temperature (°F)
T_{min} = minimum diurnal temperature (°F)

$$V_{100}\ (psi) = 1.0223 \times RVP + [(0.0357 \text{ X } RVP)/(1-0.0368 \times RVP)] \qquad \textbf{(Eq. 6-5)}$$

where:

V_{100} = vapor pressure at 100°F
RVP = Reid Vapor Pressure of the fuel

$$E_{100}\ (\%) = 66.401-12.718 \times V_{100} +1.3067 \times V_{100}^2 - 0.077934 \times V_{100}^3 + 0.0018407 \times V_{100}^4 \qquad \textbf{(Eq. 6-6)}$$

$$D_{min}\ (\%) = E_{100} + [(262 / (0.1667 * E_{100} + 560) - 0.113] \times (100 - T_{min}) \qquad \textbf{(Eq. 6-7a)}$$

$$D_{max}\ (\%) = E_{100} + [(262 / (0.1667 * E_{100} + 560) - 0.113] \times (100 - T_1) \qquad \textbf{(Eq. 6-7b)}$$

where:

$D_{min/max}$ = distillation percent at the max/min temperatures in the fuel tank
E_{100} = percent of fuel evaporated at 100°F from equation 6-6

$$P_I\ (psi) = 14.697 - 0.53089 \times D_{min} + 0.0077215 \times D_{min}^2 - 0.000055631 \times D_{min}^3 + 0.0000001769 \times D_{min}^4 \qquad \textbf{(Eq. 6-8a)}$$

$$P_F\ (psi) = 14.697 - 0.53089 \times D_{max} + 0.0077215 \times D_{max}^2 - 0.000055631 \times D_{max}^3 + 0.0000001769 \times D_{max}^4 \qquad \textbf{(Eq. 6-8b)}$$

$$\text{Density (lb/gal)} = 6.386 - 0.0186 \times \text{RVP} \qquad \textbf{(Eq. 6-9)}$$

$$\text{MW (lb/lb mole)} = (73.23 - 1.274 \times \text{RVP}) + [0.5 \times (T_{min} + T_1) - 60] \times 0.059 \qquad \textbf{(Eq. 6-10)}$$

$$\begin{aligned}\text{Diurnal emissions (grams)} = {} & \text{vapor space} \times 454 \times \text{density} \times [520 / (690 - 4 \times \text{MW})] \\ & \times 0.5 \times [P_I / (14.7 - P_I) + P_F / (14.7 - P_F)] \\ & \times [(14.7 - P_I) / (T_{min} + 460) - (14.7 - P_F) / (T_1 + 460)] \qquad \textbf{(Eq. 6-11)}\end{aligned}$$

where:

MW = molecular weight of hydrocarbons from equation 6-10
$P_{I/F}$ = initial and final pressures from equation 6-8

We use these same equations in our modeling of evaporative emissions from on-highway vehicles. However for on-highway applications we make a correction of 0.78 based on empirical data.[8] Because this correction is based on automotive applications we do not apply this correction factor here. Instead we use a correction factor of 0.65 which is based on the data we collected on exposed fuel tanks vented through a hose. This test data is presented in Table 6.1.2-1 compared to calculated theoretical results.

Table 6.1.2-1
Baseline Diurnal Evaporative Emission Results (varied temperature)

Fuel Tank Capacity	Evaporative HC [g/gallon/day]	Wade HC [g/gallon/day]	ratio of measured to Wade
17 gallons	1.39	2.3	0.6
24 gallons	1.5	2.3	0.65

Title 40, Section 80.27 of the Code of Federal Regulations specifies the maximum allowable fuel vapor pressure allowed for each state in the U.S. for each month of the year. We used these limits as an estimate of fuel vapor pressure in our calculations.

6.1.2.3 Refueling Vapor Displacement

We used the draft NONROAD model to determine the amount of fuel consumed by recreational vehicles. To calculate refueling emissions, we used an empirical equation to calculate grams of vapor displaced during refueling events. This equation was developed based on testing of 22 highway vehicles under various refueling scenarios and in the benefits calculations for our onboard refueling vapor recovery rulemaking for cars and trucks.[9] These calculations are a function of fuel vapor pressure, ambient temperature, and dispensed fuel temperature. The refueling vapor generation equation is as follows:

$$\text{Refueling vapor (g/gal)} = \text{EXP}(-1.2798 - 0.0049 \times (\text{Td} - \text{Ta}) + 0.0203 \times \text{Td} + 0.1315 \times \text{RVP}) \qquad \textbf{(Eq. 6-12)}$$

where:
Td = dispensed fuel temperature (°F)
Ta = ambient fuel temperature (°F)
RVP = Reid Vapor Pressure of the fuel

6.2 Effect of Emission Controls by Engine/Vehicle Type

The remainder of this chapter discusses the inventory results for each of the classes of engines/vehicles included in this document. These inventory projections include both exhaust and evaporative emissions. Also, this section describes inputs and methodologies used for the inventory calculations that are specific to each engine/vehicle class.

6.2.1 Compression-Ignition Recreational Marine

We projected the annual tons of exhaust HC, CO, NOx, and PM from CI recreational marine engines using the draft NONROAD model discussed above. This section describes inputs to the calculations that are specific to CI recreational marine engines then presents the results. These results are for the nation as a whole and include baseline and control inventory projections.

6.2.1.1 Inputs for the Inventory Calculations

Several usage inputs are specific to the calculations for CI recreational marine exhaust emissions. These inputs are load factor, annual use, average operating life, and population. Based on data collected in developing the draft NONROAD model, we use a load factor of 35 percent, an annual usage factor of 200 hours, and an average operating life of 20 years. The draft NONROAD model includes current and projected engine populations. Table 6.2.1-1 presents these population estimates for selected years. These population estimates have been updated since the NPRM using new data collected from the boating industry discussed in Chapter 2.

Table 6.2.1-1
Projected CI Recreational Marine Population by Year

Year	2000	2005	2010	2020	2030
population	261,000	301,000	340,000	419,000	497,000

We used the data presented in Chapter 4 to develop the baseline emission factors. For the control emission factors, we projected that the manufacturers will design their engines to meet the standard at regulatory useful life with a small compliance margin. (The regulatory useful life is the period of time for which a manufacturer must demonstrate compliance with the emission standards.) To determine the HC and NOx split for the standards, we used the HC and NOx data presented in Chapter 4 from CI recreational marine engines near the standards. Consistent with our modeling of heavy-duty highway emissions, we assumed a compliance margin of 8 percent. This compliance margin is based on historical practices for highway and nonroad engines with similar technology. Engine manufacturers give themselves some cushion below the certification level on average so that engine-to-engine variability will not cause a significant number of engines to exceed the standard. Also, we used the deterioration factors in the draft NONROAD model which have been updated since the NPRM; the only significant update is to the PM deterioration factor which is now larger. Table 6.2.1-2 presents the emission factors used in this analysis for new engines and for engines deteriorated to the regulatory useful life (10 years).

Table 6.2.1-2
Emission Factors for CI Recreational Marine Engines

Engine Technology	HC [g/kW-hr]		NOx [g/kW-hr]		CO [g/kW-hr]		PM [g/kW-hr]	
	new	10 yrs	new	10 yrs	new	10 yrs	new	10 yrs
baseline	0.295	0.300	8.94	9.05	1.27	1.39	0.219	0.270
controlled:								
< 0.9 liters/cylinder	0.181	0.184	6.69	6.72	1.27	1.39	0.219	0.270
0.9-1.2 liters/cylinder	0.181	0.184	6.41	6.44	1.27	1.39	0.219	0.270
≥ 1.2 liters/cylinder	0.182	0.184	6.42	6.44	1.27	1.39	0.181	0.184

In our analysis of the CI recreational marine engine emissions inventory, we may underestimate emissions, especially PM, due to engine deterioration in-use. We believe that current modeling only represents properly maintained engines, but may not be representative of in-use tampering or malmaintenance. However, we have not fully evaluated the limited data currently available and we are in the process of collecting more data on in-use emission deterioration. Once this has been completed we will decide whether or not we need to update our deterioration rates both in this analysis and in the Draft NONROAD model.

6.2.1.2 Reductions Due to the Standard

We anticipate that the standards will result in a 28 percent reduction in HC+NOx and a 25 percent reduction in PM in 2030. We are not claiming any benefits from the cap on CO emissions. The following tables present our projected exhaust emission inventories for CI recreational marine engines and the anticipated emission reductions.

Table 6.2.1-3
Projected HC Reductions for CI Recreational Marine Engines [short tons]

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	1,270	1,270	0	0%
2005	1,460	1,460	0	0%
2010	1,650	1,490	159	10%
2020	2,030	1,450	575	28%
2030	2,410	1,510	899	37%

Table 6.2.1-4
Projected NOx Reductions for CI Recreational Marine Engines [short tons]

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	38,000	38,000	0	0%
2005	43,600	43,600	0	0%
2010	49,400	45,800	3,550	7%
2020	60,800	48,000	12,800	21%
2030	72,200	52,200	20,000	28%

Table 6.2.1-5
Projected PM Reductions for CI Recreational Marine Engines [short tons]

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	1,000	1,000	0	0%
2005	1,150	1,150	0	0%
2010	1,300	1,230	75	6%
2020	1,600	1,310	294	18%
2030	1,900	1,420	478	25%

6.2.1.3 Per Vessel Emissions from CI Recreational Marine Engines

This section describes the development of the HC plus NOx emission estimates on a per engine basis over the average lifetime of typical CI recreational marine engines. As in the cost analysis in Chapter 5, we look at three engine sizes for this analysis (100, 400, and 750 kW) as well as a composite of all engine sizes. The emission estimates were developed to estimate the cost per ton of the standards as presented in Chapter 7.

The new and deteriorated emission factors used to calculate the HC and NOx emissions from typical CI recreational marine engines were presented in Table 6.2.1-2. A brand new engine emits at the zero-mile level presented in the table. As the engine ages, the emission levels increase based on the pollutant-specific deterioration factor. The load factor for these engines is estimated to be 0.35, the annual usage rate is estimated to be 200 hours per year, and the average lifetime is estimated to be 20 years.

Using the information described above and the equation used for calculating emissions from nonroad engines (see Equation 6-1), we calculated the lifetime HC+NOx emissions from typical marine engines both baseline and controlled engines. Table 6.2.1-6 presents these results with and without the consideration of a 7 percent per year discount on the value of emission reductions.

Table 6.2.1-6
Lifetime HC+NOx Emissions from Typical CI Recreational Marine Engines (tons)

Engine Size	Baseline		Control		Reduction	
	Undiscounted	Discounted	Undiscounted	Discounted	Undiscounted	Discounted
100 kW	1.44	0.82	1.01	0.57	0.43	0.24
400 kW	5.78	3.26	4.06	2.30	1.72	0.97
750 kW	7.18	4.53	5.08	3.20	2.10	1.32
Composite	2.58	1.47	1.81	1.03	0.77	0.44

6.2.1.4 Crankcase Emissions from CI Recreational Marine Engines

We anticipate some benefits in HC, NOx, and PM from the closed crankcase requirements for CI recreational marine engines. Based on limited engine testing, we estimate that crankcase emissions of HC and PM diesel engines are each about 0.013 g/kW-hr.[10] NOx data varies, but crankcase NOx emissions may be as high as HC and PM. Therefore, we use the same crankcase emission factor of 0.013 g/kW-hr for each of the three constituents.

For this analysis, we assume that manufacturers will use the low cost option of routing crankcase emissions to the exhaust and including them in the total exhaust emissions when the engine is designed to the standards. Because exhaust emissions must be reduced slightly to offset any crankcase emissions, the crankcase emission control is functionally equivalent to a 100 percent reduction in crankcase emissions.

The engine data we use to determine crankcase emission levels is based on new heavy-duty engines. We do not have data on the effect of in-use deterioration of crankcase emissions. However, we expect that these emissions increase as the engine wears. Therefore, this analysis may underestimate the benefits that would result from our crankcase emission requirements. Table 6.2.1-7 presents our estimates of the fleetwide reductions crankcase emissions from CI recreational marine engines.

Table 6.2.1-7
Crankcase Emissions Reductions from CI Recreational Marine Engines [short tons]

Calendar Year	HC+NOx	PM
2000	0	0
2005	0	0
2010	39	19
2020	145	73
2030	260	130

6.2.2 Large Spark-Ignition Equipment

6.2.2.1 Exhaust Emissions from Large SI Equipment

We projected the annual tons of exhaust HC, CO, and NOx from large industrial spark-ignition (SI) engines using the draft NONROAD model described above. This section describes inputs to the calculations that are specific to these engines then presents the results of the modeling.

6.2.2.1.1 Inputs for Exhaust Inventory Calculations

Several usage inputs are specific to the calculations for Large SI engines. These inputs are load factor, annual use, average operating life, and population. Because the Large SI category is made up of many applications, the NONROAD model contains application-specific information for each of the applications making up the Large SI category. Table 6.2.2-1 presents the inputs used in the NONROAD model for each of the Large SI applications. (The average operating life for a given application can vary within an application by power category. In such cases, the average operating life value presented in Table 6.2.2-1 is based on the average operating life estimate for the engine with the average horsepower listed in the table.)

The NONROAD model generally uses population data based on information from Power Systems Research, which is based on historical sales information adjusted according to survival and scrappage rates. We are, however, using different population estimates for forklifts based on a recent market study.[11] That study identified a 1996 population of 491,321 for Class 4 through 6 forklifts, which includes all forklifts powered by internal combustion engines. Approximately 80 percent of those were estimated to be fueled by propane, with the rest running on either gasoline or diesel fuel. Assuming an even split between gasoline and diesel for these remaining forklifts leads to a total population of spark-ignition forklifts of 442,000. The NONROAD model therefore uses this estimate for the forklift population, which is significantly higher than that estimated by Power Systems Research. Table 6.2.2-1 shows the estimated population figures used in the NONROAD model for each application, adjusted for the year 2000.

The split between LPG and gasoline in various applications warrants further attention. Engines are typically sold without fuel systems, which makes it difficult to assess the distribution of engines sales by fuel type. Also, engines are often retrofitted for a different fuel after a period of operation, making it still more difficult to estimate the prevalence of the different fuels. The high percentage of propane systems for forklifts, compared with about 60 percent estimated by Power Systems Research, can be largely attributed to expenses related to maintaining fuel supplies. LPG cylinders can be readily exchanged with minimal infrastructure cost as compared to gasoline storage. Natural gas systems typically offer the advantage of pipeline service, but the cost of installing high-pressure refueling equipment is an obstacle to increased use of natural gas systems.

Some applications of nonroad SI equipment face much different refueling situations.

Lawn and garden equipment is usually not centrally fueled and therefore operates almost exclusively on gasoline, which is more readily available. Agriculture equipment is predominantly powered by diesel engines. Most of these operators likely have storage tanks for diesel fuel. For those who use spark-ignition engines in addition to, or instead of, the diesel models, we expect them in many cases to be ready to invest in gasoline storage tanks as well, resulting in little or no use of LPG or natural gas for those applications. For construction, general industrial, and other equipment, there may be a mix of central and noncentral fueling, and motive and portable equipment. We therefore believe that estimating an even mix of LPG and gasoline for these engines is most appropriate. The approximate distribution of fuel types for the individual applications used in the NONROAD model are listed in Table 6.2.2-1.

Table 6.2.2-1
Operating Parameters and Population Estimates for Various Large SI Applications

Application	Avg. Rated HP	Load Factor	Hours per Year	Average Operating Life (yrs)	2000 Population	Percent LPG/CNG
Forklift	69	0.30	1800	8.3	499,693	95
Generator	59	0.68	115	25.0	143,705	100
Commercial turf	28	0.60	682	3.7	55,433	0
Aerial lift	52	0.46	361	18.1	38,637	50
Pump	45	0.69	221	9.8	35,541	50
Welder	67	0.68	408	12.7	19,006	50
Baler	44	0.62	68	25.0	18,635	0
Air compressor	65	0.56	484	11.1	17,261	50
Scrubber/sweeper	49	0.71	516	4.1	13,272	50
Chipper/grinder	66	0.78	488	7.9	13,000	50
Swathers	95	0.52	95	25.0	12,030	0
Leaf blower/vacuum	79	0.94	282	11.3	11,797	0
Sprayers	66	0.65	80	25.0	9,429	0
Specialty vehicle/cart	66	0.58	65	25.0	9,145	50
Oil field equipment	44	0.90	1104	1.5	7,855	100
Skid/steer loader	47	0.58	310	8.3	7,427	50
Other agriculture equipment	162	0.55	124	25.0	5,488	0
Irrigation set	97	0.60	716	7.0	5,176	50

Application	Avg. Rated HP	Load Factor	Hours per Year	Average Operating Life (yrs)	2000 Population	Percent LPG/CNG
Trencher	54	0.66	402	11.3	3,622	50
Rubber-tired loader	71	0.71	512	8.8	3,172	50
Other general industrial	82	0.54	713	7.8	2,922	50
Terminal tractor	93	0.78	827	4.7	2,698	50
Bore/drill rig	78	0.79	107	25.0	2,604	50
Concrete/industrial saw	46	0.78	610	3.2	2,264	50
Rough terrain forklift	66	0.63	413	11.5	1,923	50
Other material handling	67	0.53	386	7.3	1,594	50
Ag. tractor	82	0.62	550	8.8	1,597	0
Paver	48	0.66	392	5.8	1,365	50
Roller	55	0.62	621	7.8	1,360	50
Other construction	126	0.48	371	16.8	1,275	50
Crane	75	0.47	415	15.4	1,239	50
Pressure washer	39	0.85	115	15.3	1,212	50
Paving equipment	39	0.59	175	14.5	1,107	50
Aircraft support	99	0.56	681	7.9	904	50
Gas compressor	110	0.85	6000	0.8	783	100
Front mowers	32	0.65	86	25.0	658	0
Other lawn & garden	61	0.58	61	25.0	402	0
Tractor/loader/backhoe	58	0.48	870	7.2	359	50
Hydro power unit	50	0.56	450	6.0	331	50
Surfacing equipment	40	0.49	488	6.3	313	50
Railway maintenance	33	0.62	184	13.1	276	50
Crushing/processing equip	63	0.85	241	14.6	235	50
Refrigeration/AC	55	0.46	605	10.8	169	100
Dumpers/tenders	66	0.41	127	25.0	124	0
Combines	123	0.74	125	25.0	31	0

An additional issue related to population figures is the level of growth factored into emission estimates for the future. The NONROAD model incorporates application-specific growth figures based on projections from Power Systems Research. The model projects growth rates separately for the different fuels for each application. Table 6.2.2-2 presents the population estimates of Large SI engines (rounded to the nearest 1,000 units) by fuel type for selected years.

Table 6.2.2-2
Projected Large SI Population by Year

Category	2000	2005	2010	2020	2030
Gasoline LSI	224,000	232,000	240,000	261,000	294,000
LPG LSI	645,000	766,000	890,000	1,132,000	1,364,000
CNG LSI	88,000	97,000	108,000	132,000	155,000
Total LSI	957,000	1,095,000	1,238,000	1,525,000	1,813,000

Southwest Research Institute recently compiled a listing of test data from past and current testing projects.[12] These tests were all conducted on new or nearly new engines and are used in the NONROAD model as zero-mile levels (ZML). Table 6.2.2-3 summarizes this test data by fuel type. (The emission levels for gasoline engines are a population-weighted average of the water-cooled and air-cooled average emission levels, assuming air-cooled engines are 3 percent of all large spark-ignition engines, or 13 percent of gasoline large spark-ignition engines.) All engines were operated on the steady-state ISO C2 duty cycle, except for two engines that were tested on the steady-state D2 cycle. The results from the different duty cycles were comparable. Lacking adequate test data for engines fueled by natural gas, we model those engines to have the same emission levels as those fueled by liquefied petroleum gas (LPG), based on the similarity between engines using the two fuels (in the case of hydrocarbon emissions, the equivalence is based on non-methane hydrocarbons).

Emission levels often change as an engine ages. In most cases, emission levels increase with time, especially for engines equipped with technologies for controlling emissions. We developed deterioration factors for uncontrolled Large SI engines based on measurements with comparable highway engines.[13] Table 6.2.2-3 also shows the deterioration factors that apply at the median lifetime estimated for each type of equipment. For example, a deterioration factor of 1.26 for hydrocarbons multiplied by the emission factor of 6.2 g/hp-hr for new gasoline engines indicates that modeled emission levels increase to 7.8 g/hp-hr when the engine reaches its median lifetime. The deterioration factors are linear multipliers, so the modeled deterioration at different points can be calculated by simple interpolation.

Emissions during transient operation can be significantly higher than during steady-state operation. Based on emission measurements from highway engines comparable to uncontrolled

Large SI engines, we have measured transient emission levels that are 30 percent higher for HC and 45 percent higher for CO relative to steady-state measurements.[14] The NONROAD model therefore multiplies steady-state emission factors by a transient adjustment factor (TAF) of 1.3 for HC and 1.45 for CO to estimate emission levels during normal, transient operation. Test data do not support adjusting NOx emission levels for transient operation and so a TAF of 1.0 is used for NOx emissions. Also, the model applies no transient adjustment factor for generators, pumps, or compressors, since engines in these applications are less likely to experience transient operation.

Table 6.2.2-3
Zero-Mile Level Emission Factors (g/hp-hr), Deterioration Factors (at Median Life) and Transient Adjustment Factors for Pre-Control Large SI Engines

Fuel Category	THC			CO			NOx		
	ZML	DF	TAF	ZML	DF	TAF	ZML	DF	TAF
Gasoline	3.9	1.26	1.3	107.2	1.35	1.45	8.4	1.03	1.0
LPG	1.7	1.26	1.3	28.2	1.35	1.45	12.0	1.03	1.0
CNG	24.6	1.26	1.3	28.2	1.35	1.45	12.0	1.03	1.0

As manufacturers comply with the Phase 1 emission standards for Large SI engines, we expect the emission factors, deterioration factors and transient adjustment factors will be affected. To estimate the Phase 1 deterioration factors, we relied upon deterioration information for current Class IIb heavy-duty gasoline engines developed for the MOBILE6 emission model. Class IIb engines are the smallest heavy-duty engines and are comparable in size to many Large SI engines. They also employ catalyst/fuel system technology similar to the technologies we expect to be used on Large SI engines. To estimate the Phase 1 emission factors at zero miles, we back-calculated the emission levels based on the standards and the estimated deterioration factors, assuming manufacturers will design to meet a level 10 percent below the standard to account for variability. (The emission levels for Phase 1 gasoline engines were back-calculated from a population-weighted average of the Phase 1 standards for water-cooled and air-cooled engines, assuming 13 percent of gasoline engines are air-cooled.) Given that these engines will employ a catalyst to meet the standards, we believe a 10 percent compliance margin is appropriate. (Including a margin of compliance below the standards is a practice that manufacturers have followed historically to provide greater assurance that their engines meet emission standards in the event of a compliance audit.) Because the standards include an HC+NOx standard, we assumed the HC/NOx split would stay the same as pre-control engines at the end of the regulated useful life. Table 6.2.2-4 presents the zero-mile levels, deterioration factors used in the analysis of today's Phase 1 standards for Large SI engines. The Phase 1 standards are to take effect in 2004 for all engines.

The transient adjustment factors for Phase 1 engines were based on testing performed at Southwest Research Institute on engines that are similar to those expected to be certified under the Phase 1 standards. The testing was performed on one gasoline fueled engine and two LPG-fueled engines. A complete description of the testing performed and the results of the testing is summarized in the docket for the rulemaking.[15] Because we did not have any test results for CNG-fueled engines, the same transient adjustment factors for LPG-fueled engines were used.

Table 6.2.2-4
Zero-Mile Level Emission Factors (g/hp-hr), Deterioration Factors (at Median Life) and Transient Adjustment Factors for Phase 1 Large SI Engines

Fuel Category	THC			CO			NOx		
	ZML	DF	TAF	ZML	DF	TAF	ZML	DF	TAF
Gasoline	0.59	1.64	1.7	29.9	1.36	1.7	1.5	1.15	1.4
LPG	0.25	1.64	2.9	24.5	1.36	1.45	2.1	1.15	1.5
CNG	3.7	1.64	2.9	24.5	1.36	1.45	2.1	1.15	1.5

In a similar manner, as manufacturers comply with the Phase 2 emission standards for Large SI engines, we expect the emission factors, deterioration factors and transient adjustment factors will be affected. To estimate the Phase 2 deterioration factors, we relied upon the same information noted above for Phase 1 engines. The technologies used to comply with the Phase 2 standards are expected to be further refinements of the technologies we expect to be used on Phase 1 Large SI engines. For that reason, we are applying the Phase 1 deterioration factors to the Phase 2 engines. To estimate the Phase 2 emission factors at zero miles, we back-calculated the emission levels based on the standards and the estimated deterioration factors, assuming manufacturers will design to meet a level 10 percent below the standard to account for variability. Given that these engines will employ a catalyst to meet the standards, we believe a 10 percent compliance margin is appropriate. (Including a margin of compliance below the standards is a practice that manufacturers have followed historically to provide greater assurance that their engines meet emission standards in the event of a compliance audit.) As noted in Chapter 4, the Phase 2 CO standard for all engines (except air-cooled gasoline engines) is dependent on the HC+NOx level of the engine. For modeling purposes, we have assumed that all engines (except air-cooled gasoline engines) will certify at an equivalent HC+NOx standard of 1.7 g/kW-hr, yielding a CO standard of 7.9 g/kW-hr. Again, because the standards include an HC+NOx standard, we assumed the HC/NOx split would stay the same as pre-control engines at the end of the regulated useful life. (As with the Phase 1 emission factors, the emission levels for Phase 2 gasoline engines were back-calculated from a population-weighted average of the Phase 2 standards for water-cooled and air-cooled engines, assuming 13 percent of gasoline engines are air-cooled.) Table 6.2.2-5 present the zero-mile levels, deterioration factors used in the analysis of today's Phase 2 standards for Large SI engines. The Phase 2 standards are to take effect in 2004 for all engines.

Under the Phase 2 program for Large SI engines, the test procedure will be switched from a steady-state test to a transient test. Therefore, the in-use emission performance of Phase 2 engines should be similar to the emissions performance over the test cycle. For this reason, the transient adjustment factors for Phase 2 engines is set at 1.0 for all pollutants.

Table 6.2.2-5
Zero-Mile Level Emission Factors (g/hp-hr), Deterioration Factors (at Median Life) and Transient Adjustment Factors for Phase 2 Large SI Engines

Fuel Category	THC			CO			NOx		
	ZML	DF	TAF	ZML	DF	TAF	ZML	DF	TAF
Gasoline	0.3	1.64	1.0	11.9	1.36	1.0	0.7	1.15	1.0
LPG	0.1	1.64	1.0	3.9	1.36	1.0	0.9	1.15	1.0
CNG	1.6	1.64	1.0	3.9	1.36	1.0	0.9	1.15	1.0

6.2.2.1.2 Exhaust Emission Reductions Due to the Standards

Tables 6.2.2-6 through 6.2.2-8 present the projected HC, CO, and NOx exhaust emissions inventories respectively, assuming engines remain uncontrolled and assuming we adopt the Phase 1 and Phase 2 standards. The tables also contain estimated emission reductions for each of the pollutants. We anticipate that the standards will result in a 92 percent reduction in exhaust HC, 91 percent reduction in NOx, and a 88 percent reduction in CO by 2020

Table 6.2.2-6
Projected HC Inventories and Reductions for Large SI Engines (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	166,000	166,000	0	0%
2005	180,000	136,000	44,000	24%
2010	197,000	59,000	138,000	70%
2020	235,000	19,000	216,000	92%
2030	274,000	17,000	257,000	94%

Table 6.2.2-7
Projected CO Inventories and Reductions for Large SI Engines (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	1,734,000	1,734,000	0	0%
2005	1,873,000	1,712,000	161,000	9%
2010	2,022,000	945,000	1,077,000	53%
2020	2,336,000	277,000	2,059,000	88%
2030	2,703,000	265,000	2,438,000	90%

Table 6.2.2-8
Projected NOx Inventories and Reductions for Large SI Engines (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	308,000	308,000	0	0%
2005	348,000	273,000	75,000	21%
2010	389,000	118,000	271,000	70%
2020	472,000	43,000	429,000	91%
2030	553,000	44,000	509,000	92%

6.2.2.2 Evaporative and Crankcase Emission Control from Large SI Equipment

We projected the annual tons of hydrocarbons evaporated into the atmosphere from Large SI gasoline engines using the methodology discussed above in Section 6.1.2. These evaporative emissions include diurnal and refueling emissions. Although the standards do not specifically require the control of refueling emissions, we have included them in the modeling for completeness. We have also calculated estimates of hot-soak and running losses for Large SI gasoline engines using separate information on those emissions. Finally, we present crankcase emissions for all Large SI engines based on the NONROAD model. This section describes inputs to the calculations that are specific to Large SI engines and presents our baseline and controlled national inventory projections for evaporative and crankcase emissions.

6.2.2.2.1 Inputs for the Inventory Calculations

Several usage inputs are specific to the evaporative emission calculations for Large SI engines. These inputs are fuel tank sizes, population, and distribution throughout the nation. The draft NONROAD model includes current and projected engine populations for each state and we used this distribution as the national fuel tank distribution. Table 6.2.2-9 presents the population of Large SI gasoline engines for 1998.

Table 6.2.2-9
1998 Population of Large SI Gasoline Engines by Region

Region	Total
Northeast	87,200
Southeast	38,300
Southwest	22,700
Midwest	35,000
West	28,600
Northwest	9,200
Total	221,000

The draft NONROAD model breaks this engine distribution further into ranges of engine sizes. For each of these power ranges we apply a fuel tank size for our evaporative emission calculations based on the fuel tank sizes used in the NONROAD model.

Table 6.2.2-10 presents the baseline diurnal emission factors for the certification test conditions and a typical summer day with low vapor pressure fuel and a half-full tank.

Table 6.2.2-10
Diurnal Emission Factors for Test Conditions and Typical Summer Day

Evaporative Control	72-96°F, 9 RVP* Fuel, 40% fill	60-84°F, 8 RVP* Fuel, 50% fill
baseline	1.5 g/gallon/day	0.55 g/gallon/day

* Reid Vapor Pressure

We used the draft NONROAD model to determine the amount of fuel consumed by Large SI gasoline engines. As detailed earlier in Table 6.2.2-1, the NONROAD model has annual usage rates for all Large SI applications. Table 6.2.2-11 presents the fuel consumption estimates we used in our modeling. For 1998, the draft NONROAD model estimated that Large SI gasoline engines consumed about 300 million gallons of gasoline.

Table 6.2.2-11
Fuel Consumption Estimates used in Refueling Calculations for Large SI Gasoline Engines

Technology	BSFC, lb/hp-hr
Pre-control	0.605
Tier 1/Tier 2	0.484

To estimate inventories of hot-soak and running loss emissions from Large SI gasoline engines, we applied a factor to the diurnal emissions inventory estimates based on evaporative emission inventories prepared for the South Coast Air Quality Management District.[16] The hot soak inventory was estimated to be 3.9 times as high as the diurnal inventory, and the running loss inventory was estimated to be two-thirds of the diurnal inventory. Finally, crankcase emissions (from all Large SI engines) were generated using the draft NONROAD model.

Table 6.2.2-12 contains the baseline evaporative emission and crankcase emission inventories for Large SI engines.

Table 6.2.2-12
Baseline Evaporative and Crankcase Emissions from Large SI Equipment [short tons]

Calendar Year	Diurnal	Refueling	Hot-Soak	Running Loss	Crankcase
2000	700	1,400	2,720	470	54,550
2005	720	1,430	2,820	480	59,100
2010	750	1,520	2,920	500	64,950
2020	810	1,680	3,171	540	77,340
2030	920	1,900	3,577	610	90,180

6.2.2.2.2 Evaporative and Crankcase Emission Reductions Due to the Requirements

We anticipate that the evaporative emission requirements for Large SI engines will result in about a 90 percent reduction in diurnal, running loss emissions, and hot soak emissions. The new requirements for Large SI equipment includes an evaporative emission standard of 0.2 grams per gallon of fuel tank capacity for 24-hour day when temperatures cycle between 72° and 96° F. In our modeling, we consider a 3.0 psi pressure relief valve. In this case, the model only accounts for hydrocarbon emissions generated at pressures greater than 3.0 psi (see Equation 7). The evaporative emission requirements are scheduled to take effect in 2007 with the Tier 2 requirements, except for the hot-soak requirements which will take effect in 2004 with the Tier 1 requirements. In addition, because the fuel consumption of Large SI engines will be reduced by 20 percent, the refueling emissions will be reduced proportionally as well. The refueling benefits will be realized beginning in 2004 as the Tier 1 standards take effect. Finally, the standards also require that engines have a closed crankcase. We expect the crankcase emissions will generally be routed to the engine and combusted, nearly eliminating crankcase emissions. For modeling purposes, we have assumed that the crankcase emissions are reduced by 90 percent. The crankcase requirements are schedule to take effect in 2004 with the Tier 1 requirements.

Table 6.2.2-13 present the evaporative emission inventories and crankcase emissions inventories for Large SI engines based on the reductions in emissions noted above. The reductions are achieved over time as the fleet turns over to Tier 1 or Tier 2 engines. Table 6.2.2-14 presents the corresponding reductions in evaporative and crankcase emissions for Large SI engines due to the requirements.

Table 6.2.2-13
Control Case Evaporative and Crankcase Emissions from Large SI Equipment [short tons]

Calendar Year	Diurnal	Refueling	Hot-Soak	*Running Loss*	Crankcase
2000	700	1,400	2,720	470	54,550
2005	720	1,380	2,440	480	44,930
2010	550	1,360	1,600	370	25,170
2020	150	1,360	410	100	12,880
2030	70	1,520	260	50	9,020

Table 6.2.2-14
Reductions in Evaporative and Crankcase Emissions from Large SI Equipment [short tons]

Calendar Year	Diurnal	Refueling	Hot-Soak	Running Loss	Crankcase
2000	0	0	0	0	0
2005	0	50	380	0	14,200
2010	200	160	1,320	130	39,800
2020	670	320	2,760	450	64,500
2030	850	380	3,316	570	81,200

6.2.2.3 Per Equipment Emissions from Large SI Equipment

The following section describes the development of the HC+NOx emission estimates on a per piece of equipment basis over the average lifetime or typical Large SI piece of equipment. The emission estimates were developed to estimate the cost per ton of the standards as presented in Chapter 7. The estimates are made for an average piece of Large SI equipment for each of the three fuel groupings (gasoline, LPG, and CNG). Although the emissions vary from one nonroad application to another, we are presenting the average numbers for the purpose of determining the emission reductions associated with the standards from a typical piece of Large SI equipment over its lifetime.

In order to estimate the emission from a piece of Large SI equipment, information on the emission level of the engine, the power of the engine, the load factor of the engine, the annual hours of use of the engine, and the lifetime of the engine are needed. The values used to predict the per piece of equipment emissions for this analysis and the methodology for determining the values are described below.

The information necessary to calculate the HC and NOx emission levels of a piece of equipment over the lifetime of a typical piece of Large SI equipment were presented in Table

6.2.2-3 through Table 6.2.2-5. A brand new piece of equipment emits at the zero-mile level presented in the tables. As the equipment ages, the emission levels increase based on the pollutant-specific deterioration factor. Deterioration, as modeled in the NONROAD model, continues until the equipment reaches the median life of that equipment type. The deterioration factors presented in Table 6.2.2-3 through Table 6.2.2-5 when applied to the zero-mile levels presented in the same tables, represent the emission level of the engine at the end of its median life. The emissions at any point in time in between can be determined through interpolation. (For this analysis, the HC emissions from CNG engines is calculated on an NMHC+NOx basis, with NMHC emissions estimated to be 4.08 percent of THC emissions.)

To estimate the average power for equipment in each of the Large SI fuel groupings, we used the population estimates contained in the NONROAD model and the average horsepower information presented in Table 6.2.2-1. To simplify the calculations, we used the most common applications within each category that represent 80 percent or more of the fuel grouping population. For gasoline engines, the top ten applications with the highest populations were used. For LPG and CNG, the top four applications with the highest populations were used. Table 6.2.2-15 lists the applications used in the analysis.

Table 6.2.2-15
Large SI Applications Used in Per Equipment Analysis

Gasoline	LPG	CNG
Commercial Turf Equipment	Forklifts	Forklifts
Balers	Generator Sets	Generator Sets
Forklifts	Aerial Lifts	Other Oil Field Equipment
Aerial Lifts	Pumps	Irrigation Sets
Pumps		
Swathers		
Leafblowers/Vacuums		
Sprayers		
Welders		
Air Compressors		

Based on the applications noted above for each fuel, we calculated the population-weighted average horsepower for Large SI equipment to be 51.6 hp for gasoline equipment, 65.7 hp for LPG equipment, and 64.5 hp for CNG equipment.

To estimate the average load factor for equipment in each of the Large SI fuel groupings, we used the population estimates contained in the NONROAD model and the load factors as presented in Table 6.2.2-1. As noted above, to simplify the calculations, we used the most common applications within each category that represent 80 percent or more of the fuel grouping population. Based on the most populous applications noted above, we calculated the population-weighted average load factor for Large SI equipment to be 0.58 for gasoline equipment, 0.39 for LPG equipment, and 0.49 for CNG equipment.

To estimate the average annual hours of use for equipment in each of the Large SI fuel groupings, we used the population estimates contained in the NONROAD model and the hours per year levels as presented in Table 6.2.2-1. As noted above, to simplify the calculations, we used the most common applications within each category that represent 80 percent or more of the fuel grouping population. Based on the most populous applications noted above, we calculated the population-weighted average annual hours of use for Large SI equipment to be 534 hours for gasoline equipment, 1368 hours for LPG equipment, and 1164 hours for CNG equipment.

Finally, to estimate the average lifetime for equipment in each of the Large SI fuel groupings, we used the population estimates contained in the NONROAD model and the average operating life information as presented in Table 6.2.2-1. As noted above, to simplify the calculations, we used the most common applications within each category that represent 80 percent or more of the fuel grouping population. Based on the most populous applications noted above, we calculated the population-weighted average lifetime for Large SI equipment to be 12.3 years for gasoline equipment, 12 years for LPG equipment, and 13 years for CNG equipment.

Using the information described above and the equation used for calculating emissions from nonroad equipment (see Equation 6-1), we calculated the lifetime HC+NOx emissions from typical Large SI equipment for both pre-control engines and engines meeting the Tier 1 and Tier 2 standards. Table 6.2.2-16 presents the lifetime HC+NOx emissions for Large SI equipment on both an undiscounted and discounted basis (using a discount rate of 7 percent). Table 6.2.2-17 presents the corresponding lifetime HC+NOx emission reductions for the Tier 1 and Tier 2 standards.

Table 6.2.2-16
Lifetime HC+NOx Emissions from Typical Large SI Equipment (tons)*

Control Level	Gasoline		LPG		CNG	
	Un-discounted	Discounted	Un-discounted	Discounted	Un-discounted	Discounted
Pre-control	3.05	2.13	6.81	4.79	7.06	4.85
Tier 1	0.74	0.51	1.86	1.30	1.83	1.24
Tier 2	0.24	0.17	0.49	0.34	0.55	0.37

* For CNG engines only, the emissions are calculated on the basis of NMHC+NOx.

Table 6.2.2-17
Lifetime HC+NOx Emission Reductions from Typical Large SI Equipment (tons)*

Control Increment	Gasoline		LPG		CNG	
	Un-discounted	Discounted	Un-discounted	Discounted	Un-discounted	Discounted
Pre-control to Tier 1	2.31	1.62	4.94	3.50	5.24	3.61
Tier 1 to Tier 2	0.50	0.34	1.37	0.95	1.28	0.87

* For CNG engines only, the reductions are calculated on the basis of NMHC+NOx.

We also calculated per equipment lifetime evaporative emission reductions using an average lifetime of 13 years. For this analysis, we only consider gasoline powered equipment. We determine annual per vehicle evaporative emissions by dividing the total annual evaporative emissions for 2000 by the recreational vehicle populations shown in Table 6.2.2-9 (grown to 2000). Per vehicle emission reductions are based on the modeling described above. Table 6.2.2-18 presents these results with and without the consideration of a 7 percent per year discount on the value of emission reductions.

Table 6.2.2-18
Typical Lifetime Evaporative Emissions Per Large SI Gasoline Equipment(tons)

Evaporative Component	Baseline		Control		Reduction	
	Undiscounted	Discounted	Undiscounted	Discounted	Undiscounted	Discounted
Diurnal	0.041	0.028	0.003	0.002	0.038	0.026
Refueling	0.081	0.056	0.065	0.045	0.016	0.011
Hot Soak	0.158	0.109	0.011	0.008	0.147	0.101
Running Loss	0.027	0.019	0.002	0.001	0.025	0.017
Total	0.307	0.211	0.081	0.056	0.225	0.155

6.2.3 Snowmobile Exhaust Emissions

We projected the annual tons of exhaust HC, CO, NOx, and PM from snowmobiles using the draft NONROAD model discussed above. This section describes inputs to the calculations that are specific to snowmobiles then presents the results. These results are for the nation as a whole and include baseline and control inventory projections.

6.2.3.1 Inputs for the Inventory Calculations

Several usage inputs are specific to the calculations for snowmobile exhaust emissions. These inputs are load factor, annual use, average operating life, and population. Based on data developed for our Final Finding for recreational equipment and Large SI equipment, we use a load factor of 34 percent and an annual usage factor of 57 hours.[17] Using historical snowmobile sales information for 1970 through 2001 and nationwide snowmobile registrations, both provided by ISMA, and the scrappage curve used in the NONROAD model, we have updated our estimate of average life from 9 years (as used in the proposal) to 13 years for this analysis.[18] The draft NONROAD model includes current and projected engine populations. The growth rates used in the NONROAD model have been updated based on historical sales information (provided by ISMA) and sales projections (developed by NERA in an analysis of the proposed snowmobile standards for ISMA).[19,20] Table 6.2.3-1 presents the snowmobile population estimates (rounded to the nearest 1,000 units) for selected years.

Table 6.2.3-1
Projected Snowmobile Populations by Year

Year	2000	2005	2010	2020	2030
Population	1,622,000	2,000,000	2,407,000	3,089,000	3,377,000

The emission factors and deterioration factors for pre-control 2-stroke engines were developed for the Final Finding as noted above. For the control case emission factors (i.e., engines designed to comply with the Phase 1, Phase 2, or Phase 3 standards), we are projecting that manufacturers will use a mix of several different technologies that have significantly different emission characteristics. The three control technologies we believe will be used are a modified 2-stroke design, a direct injection 2-stroke engine, and a 4-stroke engine.

For the modified 2-stroke engine we assumed that manufacturers will design their engines to meet the Phase 1 standards at regulatory useful life with a small compliance margin. (Because we are not adopting a NOx standard for snowmobiles, we have assumed that NOx levels will remain at the pre-control levels for modified 2-stroke engines.) In determining the zero-mile levels of modified 2-stroke engines, we assumed a compliance margin of 20 percent to account for variability. (The standards for snowmobiles are not based on the use of catalysts. Engine out emissions tend to have more variability than the emissions coming from an engine equipped with a catalyst. For this reason, we are using a compliance margin of 20 percent. As noted earlier, including a margin of compliance below the standards is a practice that manufacturers have followed historically to provide greater assurance that their engines meet emission standards in the event of a compliance audit.) We have assumed that the deterioration rates of modified 2-strokes will stay the same as the deterioration rates for pre-control 2-stroke engines. Table 6.2.3-2 presents the emission factors used in this analysis for new engines and the maximum deterioration factors applied to snowmobiles operated out to their median lifetime. (For the calculations, the zero-mile levels were determined based on the pro-rated amount of deterioration expected at the regulatory lifetime, which is 300 hours for snowmobiles. As noted earlier, the regulatory useful life is the period of time for which a manufacturer must demonstrate compliance with the emission standards. The median lifetime of in-use equipment is longer than the regulatory life.)

Table 6.2.3-2
Zero-Mile Level Emission Factors (g/hp-hr) and Deterioration Factors (at Median Lifetime) for Snowmobile Engines

Engine Category/ Technology	THC		CO		NOx		PM	
	ZML	Max DF	ZML	Max DF	ZML	Max DF	ZML	Max DF
Pre-control 2-stroke	111	1.2	296	1.2	0.9	1.0	2.7	1.2
Modified 2-stroke	53.7	1.2	147	1.2	0.9	1.0	2.7	1.2
Direct Injection 2-stroke	21.8	1.2	90	1.2	2.8	1.0	0.57	1.2
4-stroke	7.8	1.15	123	1.17	9.2	1.0	0.15	1.15

Table 6.2.3-2 contains the zero-mile level and deterioration factors for direct injection 2-stroke engines and 4-stroke engines as well. The emission levels were based on the results of testing of prototype snowmobile engines employing these technologies or other similarly sized engines employing these technologies.[21]

The Phase 1 standards are phased-in with 50% of engines for 2006 and 100% of enignes for 2007. The Phase 2 standards take effect in 2010 for all engines. The Phase 3 standards take effect in 2012 for all engines. For modeling purposes, we estimated the percent of engines that will employ each of the control technologies to comply with the Phase 1, Phase 2, and Phase 3 standards. Table 6.2.3-3 contains the technology assumptions for the base case and under the Phase 1, Phase 2, and Phase 3 standards. Currently, all engines are 2-strokes. Based on discussions with manufacturers, we have assumed that manufacturers will begin introducing a limited number of direct injection 2-strokes and some 4-strokes in the coming years.

Table 6.2.3-3
Snowmobile Engine Technology Mix Under the Base and Control Cases

Scenario	Uncontrolled 2-strokes	Modified 2-stroke	Direct Injection 2-stroke	4-stroke
Current Baseline	100%	-	-	-
2006 Baseline	86%	-	7%	7%
Phase 1 (2006)	53%	30%	8.5%	8.5%
Phase 1 (2007)	20%	60%	10%	10%
Phase 2	20%	30%	35%	15%
Phase 3	10%	20%	50%	20%

6.2.3.2 Reductions Due to the Standards

We anticipate that the standards for snowmobiles will result in a 57 percent reduction in HC, a 46 percent reduction in CO, and a 42 percent reduction in PM by the year 2020. As manufacturers adopt advanced technologies that result in significant HC, CO and PM emissions, we expect the relatively limited amount of NOx from snowmobiles to increase under the program. Tables 6.2.3-4 through 6.2.3.-7 present our projected HC, CO, NOx, and PM exhaust emission inventories for snowmobiles and the anticipated emission reductions from the Phase 1, Phase 2 and Phase 3 standards.

Table 6.2.3-4
Projected HC Inventories and Reductions for Snowmobiles (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	205,000	205,000	0	0%
2005	250,000	250,000	0	0%
2010	286,000	243,000	43,000	15%
2020	345,000	148,000	197,000	57%
2030	375,000	133,000	242,000	65%

Table 6.2.3-5
Projected CO Inventories and Reductions for Snowmobiles (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	546,000	546,000	0	0%
2005	668,000	668,000	0	0%
2010	775,000	670,000	105,000	14%
2020	950,000	508,000	442,000	46%
2030	1,035,000	497,000	538,000	52%

Table 6.2.3-6
Projected NOx Inventories and Reductions for Snowmobiles (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	1,400	1,400	0	0%
2005	1,900	1,900	0	0%
2010	3,000	3,500	(500)	-16%
2020	5,000	10,000	(5,000)	-101%
2030	5,500	12,100	(6,600)	-121%

Table 6.2.3-7
Projected PM Inventories and Reductions for Snowmobiles (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	5,000	5,000	0	0%
2005	6,100	6,100	0	0%
2010	7,000	6,700	300	4%
2020	8,400	4,900	3,500	42%
2030	9,100	4,400	4,700	52%

6.2.3.3 Per Equipment Emissions from Snowmobiles

The following section describes the development of the HC and CO emission estimates on a per piece of equipment basis over the average lifetime or a typical snowmobile. The emission estimates were developed to estimate the cost per ton of the standards as presented in

Chapter 7.

In order to estimate the emission from a snowmobile, information on the emission level of the engine, the power of the engine, the load factor of the engine, the annual hours of use of the engine, and the lifetime of the engine are needed. The values used to predict the per piece of equipment emissions for this analysis and the methodology for determining the values are described below.

The information necessary to calculate the HC and CO emission levels of a piece of equipment over the lifetime of a typical snowmobile were presented in Table 6.2.3-2. A brand new snowmobile emits at the zero-mile level presented in the table. As the snowmobile ages, the emission levels increase based on the pollutant-specific deterioration factor. Deterioration, as modeled in the NONROAD model, continues until the equipment reaches the median life. The deterioration factors presented in Table 6.2.3-2 when applied to the zero-mile levels presented in the same table, represent the emission level of the snowmobile at the end of its median life. The emissions at any point in time in between can be determined through interpolation.

To estimate the average power for snowmobiles, we used the population and power distribution information contained in the NONROAD model and determined the population-weighted average horsepower for snowmobiles. The population-weighted horsepower for snowmobiles was calculated to be 48.3 hp.

As described earlier in this section, the load factor for snowmobiles is estimated to be 0.34, the annual usage rate is estimated to be 57 hours per year, and the average lifetime is estimated to be 13 years.

Using the information described above and the equation used for calculating emissions from nonroad equipment (see Equation 6-1), we calculated the lifetime HC and CO emissions from a typical snowmobile for both pre-control engines and engines meeting the Phase 1, Phase 2, and Phase 3 standards. (The per vehicle estimates are a weighted-average of the different technologies assumed under the base and control cases as presented earlier in Table 6.2.3-3.) Table 6.2.3-8 presents the lifetime HC and CO emissions for a typical snowmobile on both an undiscounted and discounted basis (using a discount rate of 7 percent). Table 6.2.3-9 presents the corresponding lifetime HC and CO emission reductions for the Phase 1, Phase 2 and Phase 3 standards.

Table 6.2.3-8
Lifetime HC and CO Emissions from a Typical Snowmobile (tons)

Control Level	HC		CO	
	Undiscounted	Discounted	Undiscounted	Discounted
Pre-control	1.45	0.98	3.99	2.71
Phase 1	0.85	0.57	2.50	1.70
Phase 2	0.70	0.47	2.27	1.54
Phase 3	0.51	0.34	1.90	1.29

Table 6.2.3-9
Lifetime HC and CO Emission Reductions from a Typical Snowmobile (tons)

Control Increment	HC		CO	
	Undiscounted	Discounted	Undiscounted	Discounted
Pre-control to Phase 1	0.60	0.40	1.49	1.01
Phase 1 to Phase 2	0.15	0.10	0.23	0.16
Phase 2 to Phase 3	0.19	0.14	0.37	0.25

6.2.4 All-Terrain Vehicle Exhaust Emissions

We projected the annual tons of exhaust HC, CO, NOx, and PM from all-terrain vehicles (ATVs) using the draft NONROAD model discussed above. This section describes inputs to the calculations that are specific to ATVs then presents the results. These results are for the nation as a whole and include baseline and control inventory projections.

6.2.4.1 Inputs for the Inventory Calculations

Several usage inputs are specific to the calculations for ATV exhaust emissions. These inputs are annual use, average operating life, and population. Based on data developed for our Final Finding for recreational equipment and Large SI equipment, we use an average operating life of 13 years for ATVs.[22] Based on several surveys of ATV operators, we have revised the an annual usage factor for ATVs for this analysis to 1,570 miles per year.[23] The updated mileage analysis for ATVs is presented in detail in the appendix to this chapter. (Because the ATV standards are chassis-based standards instead of engine-based, the NONROAD model has been revised to model ATVs on the basis of gram per mile emission factors and annual mileage accumulation rates. Load factor is not needed for such calculations.)

The draft NONROAD model includes current and projected engine populations. Table

6.2.4-1 presents these population estimates (rounded to the nearest 1,000 units) for selected years. The ATV population growth rates used in the NONROAD model have been updated for this analysis to reflect the expected growth in ATV populations based on updated ATV sales information and sales growth projections supplied by the Motorcycle Industry Council (MIC), an industry trade organization. The growth rates were developed separately for 2-stroke and 4-stroke ATVs. Based on the sales information from MIC, sales of ATVs have been growing substantially throughout the 1990s, averaging 25 percent growth per year over the last 6 years. MIC estimates that growth in sales will continue for the next few years, although at lower levels of ten percent or less, with no growth in sales projected by 2005. Combining the sales history, growth projections, and information on equipment scrappage, we have estimated that the population of ATVs will grow significantly through 2010, and then grow at much lower levels.[24] (The population of 2-stroke ATVs presented in Table 6.2.4-1 are for baseline population estimates. Under the ATV standards, 2-stroke designs are expected to be phased-out as they are converted to 4-stroke designs.)

Table 6.2.4-1
Projected ATV Populations by Year

Category	2000	2005	2010	2020	2030
4-stroke ATVs	3,919,000	6,240,000	8,453,000	10,080,000	10,188,000
2-stroke ATVs*	690,000	1,678,000	2,461,000	3,001,000	3,036,000
All ATVs	4,609,000	7,918,000	10,914,000	13,081,000	13,224,000

* - The projected population estimates for 2-stroke ATVs are for baseline calculations only. Under the Phase 1 standards, we expect all 2-stroke engines will be converted to 4-stroke designs.

The baseline HC, CO, and NOx emission factors used in the NONROAD model for ATVs have been updated based on recent testing of ATVs and off-highway motorcycles as presented in Chapter 4. PM emissions were not measured in the test program. Therefore, baseline PM emission factors were based on testing of both off-highway motorcycles and pre-control on-highway motorcycles.[25] The baseline deterioration factors (for pre-control engines) were developed for the Final Finding as noted above. For the control emission factors (i.e., engines complying with the Phase 1 standards), we assumed that the manufacturers will design their engines to meet the standards at regulatory useful life with a small compliance margin. Because we are adopting a HC+NOx standard for ATVs, we have assumed that the Phase 1 HC/NOx split will remain the same as the pre-control HC/NOx split. For the Phase 1 standards for ATVs, we assumed a compliance margin of 20 percent to account for variability. (As noted earlier, including a margin of compliance below the standards is a practice that manufacturers have followed historically to provide greater assurance that their engines will meet emission standards in the event of a compliance audit.) Because the standards for ATVs are expected to be met by 4-stroke designs, we assumed that the deterioration rates will stay the same as the deterioration rates for pre-control 4-stroke ATVs. Table 6.2.4-2 presents the emission factors used in this analysis for new ATVs and the maximum deterioration factors for ATVs which applies at the median lifetime. (For the calculations, the zero-mile levels were determined based on the pro-rated amount of deterioration expected at the regulatory lifetime, which is 6,214 miles (10,000 kilometers) for ATVs. As noted earlier, the regulatory useful life is the period of time for which a manufacturer must demonstrate compliance with the emission standards. The median lifetime of in-use equipment is longer than the regulatory life. As noted earlier, the regulatory useful life is the period of time for which a manufacturer must demonstrate compliance with the emission standards. The median lifetime of in-use equipment is longer than the regulatory life.)

Table 6.2.4-2
Zero-Mile Level Emission Factors (g/mi) and Deterioration Factors (at Median Lifetime) for ATVs

Engine Category	THC		CO		NOx		PM	
	ZML	Max DF	ZML	Max DF	ZML	Max DF	ZML	Max DF
Baseline/Pre-control 2-stroke	53.9	1.2	54.1	1.2	0.15	1.0	2.1	1.2
Baseline/Pre-control 4-stroke	2.4	1.15	48.5	1.17	0.41	1.0	0.06	1.2
Control/Phase 1 - 4-stroke	1.6	1.15	42.9	1.17	0.26	1.0	0.06	1.15

The Phase 1 standards are to be phased in at 50 percent in 2007 and 100 percent in 2008. However, because there are a significant number of small volume manufacturers that produce 2-stroke ATVs, and because we have compliance flexibilities for such manufacturers, we have modeled the phase in of the standards for the current 2-stroke ATVs based on the schedule contained in Table 6.2.4-3.

Table 6.2.4-3
Assumed Phase-In Schedule for Current 2-Stroke ATVs Used in the Modeling Runs

Model Year	Pre-control 2-stroke	Phase 1 4-stroke
2005	100%	0%
2006	65%	35%
2007	30%	70%
2008	15%	85%
2009	0%	100%

6.2.4.2 Reductions Due to the Standards

We anticipate that the standards for ATVs will result in a 86 percent reduction in HC, a 37 percent reduction in CO, and a 86 percent reduction in PM by the year 2020. As manufacturers convert their engines from 2-stroke to 4-stroke design and achieve these significant reductions, we expect there may be a minimal increase in NOx. Tables 6.2.4-4 through 6.2.4-7 present our projected HC, CO, NOx, and PM exhaust emission inventories for ATVs and the anticipated emission reductions from the Phase 1 standards.

Table 6.2.4-4
Projected HC Inventories and Reductions for ATVs (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	89,000	89,000	0	0%
2005	200,000	200,000	0	0%
2010	291,000	198,000	92,000	32%
2020	353,000	49,000	304,000	86%
2030	357,000	40,000	317,000	89%

Table 6.2.4-5
Projected CO Inventories and Reductions for ATVs (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	437,000	437,000	0	0%
2005	755,000	755,000	0	0%
2010	1,042,000	989,000	53,000	5%
2020	1,250,000	1,085,000	165,000	13%
2030	1,263,000	1,092,000	171,000	14%

Table 6.2.4-6
Projected NOx Inventories and Reductions for ATVs (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	3,000	3,000	0	0%
2005	4,900	4,900	0	0%
2010	6,600	5,900	(700)	-11%
2020	7,900	5,900	(2,000)	-25%
2030	8,000	6,000	(2,000)	-26%

Table 6.2.4-7
Projected PM Inventories and Reductions for ATVs (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	3,200	3,200	0	0%
2005	7,400	7,400	0	0%
2010	10,800	7,400	3,400	32%
2020	13,100	1,800	11,300	86%
2030	13,300	1,500	11,800	89%

6.2.4.3 Per Equipment Emissions from All-Terrain Vehicles

The following section describes the development of the HC+NOx emission estimates on a per piece of equipment basis over the average lifetime or a typical ATV. The emission estimates were developed to estimate the cost per ton of the standards as presented in Chapter 7.

In order to estimate the emissions from an ATV, information on the emission level of the vehicle, the annual usage rate of the engine, and the lifetime of the engine are needed. The values used to predict the per piece of equipment emissions for this analysis and the methodology for determining the values are described below.

The information necessary to calculate the HC and NOx emission levels of a piece of equipment over the lifetime of a typical ATV were presented in Table 6.2.4-2. A brand new ATV emits at the zero-mile level presented in the table. As the ATV ages, the emission levels increase based on the pollutant-specific deterioration factor. Deterioration, as modeled in the NONROAD model, continues until the equipment reaches the median life. The deterioration factors presented in Table 6.2.4-2 when applied to the zero-mile levels presented in the same table, represent the emission level of the ATV at the end of its median life. The emissions at any point in time in between can be determined through interpolation.

As described earlier in this section, the annual usage rate for an ATV is estimated to be 1,570 miles per year and the average lifetime is estimated to be 13 years.

Using the information described above and the equation used for calculating emissions from nonroad equipment modified to remove the power and load variables (see Equation 6-1), we calculated the lifetime HC+NOx emissions from a typical ATV for both pre-control engines (shown separately for 2-stroke and 4-stroke engines and a composite weighted value) and engines meeting the Phase 1 standards. Table 6.2.4-8 presents the lifetime HC+NOx emissions for a typical ATV on both an undiscounted and discounted basis (using a discount rate of 7 percent). Table 6.2.4-9 presents the corresponding lifetime HC+NOx emission reductions for the Phase 1.

Table 6.2.4-8
Lifetime HC+NOx Emissions from a Typical ATV (tons)

Control Level	HC+NOx	
	Undiscounted	Discounted
Pre-control (2-stroke)	1.37	0.93
Pre-control (4-stroke)	0.07	0.05
Pre-control (Composite)	0.35	0.24
Phase 1	0.05	0.03

Table 6.2.4-9
Lifetime HC+NOx Emission Reductions from a Typical ATV (tons)

Control Increment	HC+NOx	
	Undiscounted	Discounted
Pre-control (Composite) to Phase 1	0.30	0.21

6.2.5 Off-highway Motorcycle Exhaust Emissions

We projected the annual tons of exhaust HC, CO, NOx, and PM from off-highway motorcycles using the draft NONROAD model discussed above. This section describes inputs to the calculations that are specific to off-highway motorcycles then presents the results. These results are for the nation as a whole and include baseline and control inventory projections.

6.2.5.1 Inputs for the Inventory Calculations

Several usage inputs are specific to the calculations for off-highway motorcycles exhaust emissions. These inputs are annual use, average operating life, and population. Based on an updated analysis of fuel consumption and fuel use, we have revised our estimate of annual usage for off-highway motorcycles to 1,600 miles per year.[26] (The updated mileage analysis for off-highway motorcycles is presented in detail in the appendix to this chapter.) We have also revised our estimate of the average operating life of off-highway motorcycles to 12 years based on historical sales and population information provided by the Motorcycle Industry Council.[27] (Because the off-highway motorcycle standards are chassis-based standard instead of engine-based, the NONROAD model has been revised to model off-highway motorcycles on the basis of gram per mile emission factors and annual mileage accumulation rates. Load factor is not needed for such calculations.)

The draft NONROAD model includes current and projected engine populations. Table 6.2.5-1 presents these population estimates (rounded to the nearest 1,000 units) for selected years. (The population of 2-stroke off-highway motorcycles presented in Table 6.2.5-1 are for baseline population estimates. Under the off-highway motorcycle standards, non-competition 2-stroke designs are expected to be phased-out as they are converted to 4-stroke designs. Competition models will remain 2-stroke designs.) The population growth rates used in the NONROAD model have been updated based on historical sales information provided by MIC and a projected one percent growth in sales.[28]

Table 6.2.5-1
Projected Off-Highway Motorcycle Populations by Year

Category	2000	2005	2010	2020	2030
4-stroke Off-highway Motorcycles	444,000	656,000	862,000	1,038,000	1,133,000
2-stroke Off-highway Motorcycles*	902,000	1,333,000	1,750,000	2,108,000	2,300,000
All Off-highway Motorcycles	1,346,000	1,989,000	2,612,000	3,146,000	3,433,000

* - The projected population estimates for 2-stroke off-highway motorcycles are for baseline calculations only. To meet the standards, we expect all non-competition 2-strokes will be converted to 4-stroke designs. All 2-stroke competition models are assumed to remain 2-strokes.

The baseline HC, CO, and NOx emission factors used in the NONROAD model for off-highway motorcycles have been updated based on recent testing of ATVs and off-highway motorcycles as presented in Chapter 4. PM emissions were not measured in the test program. Therefore, baseline PM emission factors were based on testing of both off-highway motorcycles and pre-control on-highway motorcycles.[29] The baseline deterioration factors (for pre-control engines) were developed for the Final Finding as noted above. For the control emission factors (i.e., Phase 1 off-highway motorcycles), we assumed that the manufacturers will design their engines to meet the standards at regulatory useful life with a small compliance margin. Because we are adopting a HC+NOx standard for off-highway motorcycles, we have assumed that the Phase 1 HC/NOx split will remain the same as the pre-control HC/NOx split. For the Phase 1 standards for off-highway motorcycles, we assumed a compliance margin of 20 percent to account for variability. (Including a margin of compliance below the standards is a practice that manufacturers have followed historically to provide greater assurance that their engines will meet emission standards in the event of a compliance audit.) Because the standards for off-highway motorcycles are expected to be met by 4-stroke designs, we assumed that the deterioration rates will stay the same as the deterioration rates for pre-control 4-stroke off-highway motorcycles. Table 6.2.5-2 presents the emission factors used in this analysis for new off-highway motorcycles and the maximum deterioration factors applied to off-highway motorcycles operated out to their median lifetime. (For the calculations, the zero-mile levels were determined based on the pro-rated amount of deterioration expected at the regulatory lifetime, which is 6,210 miles (10,000 kilometers) for off-highway motorcycles. As noted earlier, the regulatory useful life is the period of time for which a manufacturer must demonstrate compliance with the emission standards. The median lifetime of in-use equipment is longer than the regulatory life.)

Table 6.2.5-2
Zero-Mile Level Emission Factors (g/mi) and Deterioration Factors (at Median Lifetime) for Off-Highway Motorcycles

Engine Category	THC		CO		NOx		PM	
	ZML	Max DF	ZML	Max DF	ZML	Max DF	ZML	Max DF
Baseline/Pre-control 2-stroke*	53.9	1.2	54.1	1.2	0.15	1.0	2.1	1.2
Baseline/Pre-control 4-stroke	2.4	1.15	48.5	1.17	0.41	1.0	0.06	1.15
Control/Phase 1 4-stroke	2.1	1.15	30.6	1.17	0.34	1.0	0.06	1.15

* - Competition models are assumed to remain at pre-control levels under the final program for off-highway motorcycles.

The Phase 1 standards phase in at 50 percent in 2007 and 100 percent in 2008. However, because there are a significant number of small volume manufacturers that produce off-highway motorcycles (who can take advantage of compliance flexibilities), and because competition off-highway motorcycles are exempt from the standards, we have modeled the phase in of the standards for off-highway motorcycles based on the schedule contained in Table 6.2.5-3.

Table 6.2.5-3
Assumed Phase-In Schedule for Current Off-Highway Motorcycles Used in the Modeling Runs

Model Year	Current 4-stroke Off-highway Motorcycles		Current 2-stroke Off-highway Motorcycles	
	Pre-control	Phase 1	Pre-control	Phase 1
2005	100%	0%	100%	0%
2006	56%	44%	76%	24%
2007	12%	88%	53%	47%
2008	6%	94%	49%	51%
2009+	0%	100%	46%	54%

6.2.5.2 Reductions Due to the Standards

We anticipate that the standards for off-highway motorcycles will result in a 49 percent reduction in HC, a 26 percent reduction in CO, and a 50 percent reduction in PM by the year 2020. As manufacturers convert their engines from 2-stroke to 4-stroke design and achieve these significant emission reductions, we project there may be a small increase in NOx inventories. Tables 6.2.5-4 through 6.2.5.-7 present our projected HC, CO, NOx, and PM exhaust emission inventories for off-highway motorcycles and the anticipated emission reductions from the Phase 1 standards. (The emission inventories presented below for off-highway motorcycles include competition motorcycles that will be exempt from the standards.)

Table 6.2.5-4
Projected HC Inventories and Reductions for Off-Highway Motorcycles (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	97,000	97,000	0	0%
2005	143,000	143,000	0	0%
2010	188,000	151,000	36,000	19%
2020	226,000	115,000	111,000	49%
2030	246,000	121,000	126,000	51%

Table 6.2.5-5
Projected CO Inventories and Reductions for Off-Highway Motorcycles (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	137,000	137,000	0	0%
2005	203,000	203,000	0	0%
2010	226,000	239,000	27,000	10%
2020	321,000	236,000	84,000	26%
2030	350,000	254,000	96,000	27%

Table 6.2.5-6
Projected NOx Inventories and Reductions for Off-Highway Motorcycles (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	600	600	0	0%
2005	800	800	0	0%
2010	1,100	1,200	(100)	-8%
2020	1,300	1,500	(200)	-19%
2030	1,400	1,700	(300)	-19%

Table 6.2.5-7
Projected PM Inventories and Reductions for Off-Highway Motorcycles (short tons)

Calendar Year	Baseline	Control	Reduction	% Reduction
2000	3,700	3,700	0	0%
2005	5,500	5,500	0	0%
2010	7,300	5,900	1,400	20%
2020	8,700	4,400	4,300	50%
2030	9,500	4,600	4,900	52%

6.2.5.3 Per Equipment Emissions from Off-highway Motorcycles

The following section describes the development of the HC+NOx emission estimates on a per piece of equipment basis over the average lifetime or a typical off-highway motorcycle. The emission estimates were developed to estimate the cost per ton of the standards as presented in Chapter 7.

In order to estimate the emissions from an off-highway motorcycle, information on the emission level of the vehicle, the annual usage rate of the engine, and the lifetime of the engine are needed. The values used to predict the per piece of equipment emissions for this analysis and the methodology for determining the values are described below.

The information necessary to calculate the HC and NOx emission levels of a piece of equipment over the lifetime of a typical off-highway motorcycle were presented in Table 6.2.5-2. A brand new off-highway motorcycle emits at the zero-mile level presented in the table. As the off-highway motorcycle ages, the emission levels increase based on the pollutant-specific deterioration factor. Deterioration, as modeled in the NONROAD model, continues until the equipment reaches the median life. The deterioration factors presented in Table 6.2.5-2 when applied to the zero-mile levels presented in the same table, represent the emission level of the off-highway motorcycle at the end of its median life. The emissions at any point in time in between can be determined through interpolation.

As described earlier in this section, the annual usage rate for an off-highway motorcycle is estimated to be 1,600 miles per year and the average lifetime is estimated to be 12 years.

Using the information described above and the equation used for calculating emissions from nonroad equipment modified to remove the power and load variables (see Equation 6-1), we calculated the lifetime HC+NOx emissions from a typical off-highway motorcycle for both pre-control engines (shown separately for 2-stroke and 4-stroke engines and a composite weighted value) and engines under the Phase 1 standards. (Competition bikes, which are exempt from the standards, are not included in the calculations.) Table 6.2.5-8 presents the lifetime HC+NOx emissions for a typical off-highway motorcycle on both an undiscounted and discounted basis (using a discount rate of 7 percent). Table 6.2.5-9 presents the corresponding lifetime HC+NOx emission reductions for the Phase 1 standards.

Table 6.2.5-8
Lifetime HC+NOx Emissions from a Typical Off-highway Motorcycle (tons)*

Control Level	HC+NOx	
	Undiscounted	Discounted
Pre-control (2-stroke)	1.27	0.89
Pre-control (4-stroke)	0.06	0.04
Pre-control (Composite)	0.60	0.42
Phase 1	0.06	0.04

* The emission estimates do not include competition off-highway motorcycles that remain at pre-control emission levels.

Table 6.2.5-9
Lifetime HC+NOx Emission Reductions from a Typical Off-highway Motorcycle (tons)*

Control Increment	HC+NOx	
	Undiscounted	Discounted
Pre-control (Composite) to Phase 1	0.54	0.38

* The reduction estimates do not include competition off-highway motorcycles that remain uncontrolled, and therefore do not realize any emission reductions under the new standards.

6.2.6 Evaporative Emissions from Recreational Vehicles

We projected the annual tons of hydrocarbons evaporated into the atmosphere from snowmobiles, ATVs, off-highway motorcycles using the methodology discussed above in Section 6.1.2. These evaporative emissions include permeation, diurnal and refueling emissions. Although the standards do not specifically require the control of diurnal and refueling emissions, we have included them in the modeling for completeness. This section describes inputs to the calculations that are specific to each of the recreational vehicle types and presents our baseline and controlled national evaporative inventory projections.

6.2.6.1 General Inputs for the Inventory Calculations

Several usage inputs are specific to the calculations of evaporative emissions from ATVs. These inputs are fuel tank sizes, population, and distribution throughout the nation. The draft NONROAD model includes current and projected engine populations for each state and we used this distribution as the national fuel tank distribution. Table 6.2.6-1 presents the population of recreational vehicles for 1998.

Table 6.2.6-1
1998 Population of Recreational Vehicles by Region

Region	Snowmobiles	ATVs	Off-Highway Motorcycles
Northeast	954,000	1,420,000	427,000
Southeast	0	1,010,000	304,000
Southwest	11,000	363,000	109,000
Midwest	419,000	457,000	137,000
West	40,000	423,000	127,000
Northwest	140,000	249,000	75,000
Total	1,560,000	3,930,000	1,180,000

We based average fuel tank sizes on sales literature for recreational vehicles. Snowmobile fuel tanks range from 10 gallons to about 12 gallons. For ATVs, fuel tanks range from one gallon for the smaller youth models to five gallons for the larger utility models.

Finally, off-highway motorcycle fuel tanks range in capacity from approximately one gallon on some smaller youth models to about three gallons on some enduro motorcycles. For this analysis, we used average fuel tank sizes of 11 gallons for snowmobiles, 4 gallons for ATVs, and 3 gallons for off-highway motorcycles.

Based on our examination of recreational vehicles, we have found that fuel hoses generally have an inside diameter of about 6 mm (1/4 inch). For ATVs, we estimate one foot of fuel line on average. For off-highway motorcycles, we estimate that they use approximately one to two feet of fuel line on average. We use 1.5 feet in our analysis. Snowmobiles are a little more complex because they use multi-cylinder engines (either two or three cylinders). For two cylinder engines we estimate two to three feet of fuel line and for three cylinder engines we estimate three to four feet of fuel line. We use 3.5 feet in our analysis.

6.2.6.2 Permeation Emissions Inventory and Reductions

Based on the data presented in Chapter 4, we developed the emission factors presented in Table 6.2.6-2. For the purposes of this modeling, fuel tank permeation rates are expressed in terms of g/gallon/day because the defining characteristic of the fuel tanks in our model is capacity. The standard requires that the fuel tanks meet an 85 percent reduction in permeation throughout its useful life. For this modeling, we assume that manufacturers will strive to achieve a 95 percent reductions from new tanks and that the permeation control will deteriorate to 85 percent by the end of the life of an average tank. Hose permeation rates are based on g/m^2/day. We believe that hoses designed to meet the 15 g/m^2/day standard on 10 percent ethanol fuel will permeate at least 50 percent less when gasoline is used. Therefore, we model permeation from this hose to be about half of the permeation from fuel hose designed to meet 15 g/m^2/day on gasoline.[gg] To show the effect of temperature on permeation rates, we present emission rates at three temperatures.

Table 6.2.6-2
Fuel Tank and Hose Permeation Emission Factors

Material	23°C (73°F)	29°C (85°F)	40°C (104°F)
Polyethylene fuel tanks	0.78 g/gal/day	1.12 g/gal/day	2.08 g/gal/day
New barrier treated HDPE fuel tank	0.04 g/gal/day	0.06 g/gal/day	0.10 g/gal/day
Aged barrier treated HDPE fuel tank	0.11 g/gal/day	0.17 g/gal/day	0.31 g/gal/day
SAE R7 fuel hose	550 g/m^2/day	873 g/m^2/day	1800 g/m^2/day
SAE R9 barrier fuel hose	15 g/m^2/day	24 g/m^2/day	49 g/m^2/day
Alcohol resistant barrier fuel hose	7.5 g/m^2/day	12 g/m^2/day	25 g/m^2/day

[gg] This is appropriate because the baseline emissions are modeled based on the use of gasoline as a fuel. If we were to consider that a fraction of the fuel contains oxygenates, both the baseline and control emission inventory projections would increase.

Using the vehicle populations and temperature distributions discussed above, we calculated baseline and controlled permeation emission inventories for recreational vehicles. Tables 6.2.6-3 and 6.2.6-4 present our projected permeation reductions from fuel tanks and hoses.

Table 6.2.6-3
Projected Fuel Tank Permeation Emissions from Recreational Vehicles [short tons]

Vehicle	Scenario	2000	2005	2010	2020	2030
Snow-mobiles	baseline	3,389	4,181	5,032	6,456	7,061
	control	3,389	4,181	3,586	901	746
	reduction	0	0	1,446	5,555	6,315
ATVs	baseline	3,985	6,751	9,275	11,109	11,231
	control	3,985	6,751	7,388	2,602	1,249
	reduction	0	0	1,887	8,507	9,982
OHMCs	baseline	882	1,303	1,710	2,061	2,248
	control	882	1,303	1,370	834	857
	reduction	0	0	340	1,227	1,391
Total	baseline	8,255	12,234	16,016	19,626	20,539
	control	8,255	12,234	12,343	4,337	2,851
	reduction	0	0	3,673	15,288	17,688

Table 6.2.6-4
Projected Fuel Hose Permeation Emissions from Recreational Vehicles [short tons]

Vehicle	Scenario	2000	2005	2010	2020	2030
Snow-mobiles	baseline	4,471	5,516	6,638	8,517	9,315
	control	4,471	5,516	4,361	452	127
	reduction	0	0	2,007	8,065	9,188
ATVs	baseline	4,243	7,189	9,876	11,829	11,959
	control	4,243	7,189	7,771	1,931	245
	reduction	0	0	2,105	9,898	11,714
OHMCs	baseline	1,878	2,774	3,642	4,389	4,787
	control	1,878	2,774	2,880	1,513	1,520
	reduction	0	0	762	2,876	3,268
Total	baseline	10,592	15,478	20,156	24,735	26,061
	control	10,592	15,478	15,282	3,896	1,891
	reduction	0	0	4,873	20,838	24,169

6.2.6.3 Per Vehicle Permeation Emissions

In developing the cost per ton estimates in Chapter 7, we need to know the lifetime emissions per recreational vehicle. The lifetime emissions are based on the projected lives of 9 years for snowmobiles, 13 years for ATVs, and 9 years for off-highway motorcycles. We determine annual per vehicle evaporative emissions by dividing the total annual evaporative emissions for 2000 by the recreational vehicle populations shown in Table 6.2.6-1 (grown to 2000). Competition motorcycles, which are exempt form the standards, are not included in these calculations. Per vehicle emission reductions are based on the modeling described above. Table 6.2.6-5 presents these results with and without the consideration of a 7 percent per year discount on the value of emission reductions.

Table 6.2.6-5
Typical Lifetime Permeation Emissions Per Recreational Vehicle (tons)

	Baseline		Control		Reduction	
	Undiscounted	Discounted	Undiscounted	Discounted	Undiscounted	Discounted
Snowmobiles						
Tank	0.0180	0.0140	0.0019	0.0015	0.0161	0.0125
Hose	0.0238	0.0184	0.0003	0.0003	0.0235	0.0182
Total	0.0418	0.0324	0.0022	0.0017	0.0396	0.0307
All Terrain Vehicles						
Tank	0.0114	0.0078	0.0012	0.0008	0.0102	0.0070
Hose	0.0121	0.0083	0.0002	0.0001	0.0119	0.0082
Total	0.0234	0.0161	0.0014	0.0009	0.0221	0.0152
Off-Highway Motorcycles						
Tank	0.0059	0.0046	0.0006	0.0005	0.0053	0.0041
Hose	0.0126	0.0097	0.0002	0.0001	0.0124	0.0096
Total	0.0184	0.0143	0.0008	0.0006	0.0177	0.0137

6.2.6.4 Other Evaporative Emissions

We calculated diurnal and refueling vapor loss emissions using the general inputs in section 6.2.6.1 and the methodology described in sections 6.1.2.2 and 6.2.1.3. Although we are not regulating these emissions, we present the inventory projections for comparison. Table 6.2.6-6 presents the baseline diurnal emission factors for the certification test conditions and a typical summer day with low vapor pressure fuel and a half-full tank. (This comparison is for illustrative purposes; as discussed above, we modeled daily temperature for 365 days over 6 regions of the U.S.) Decreasing temperature and fuel RVP and increasing fill level all have the effect of reducing the diurnal emission factor. Table 6.2.6-7 presents our diurnal emission projections.

Table 6.2.6-6
Diurnal Emission Factors for Test Conditions and Typical Summer Day

Evaporative Control	72-96°F, 9 RVP* Fuel, 40% fill	60-84°F, 8 RVP* Fuel, 50% fill
baseline	1.5 g/gallon/day	0.55 g/gallon/day

* Reid Vapor Pressure

Table 6.2.6-7
Projected Diurnal Emissions from Recreational Vehicles [short tons]

Calendar Year	Snowmobiles	ATVs	Off-Highway Motorcycles
2000	2,223	3,079	681
2005	2,743	5,216	1,006
2010	3,301	7,167	1,321
2020	4,235	8,584	1,592
2030	4,632	8,678	1,737

To calculate the refueling vapor displacement emissions from recreational vehicles, we needed to know the amount of fuel added to the fuel tank per year. Therefore, we used the draft NONROAD model to determine the amount of fuel consumed by recreational vehicles. We then used the amount of fuel consumed as the amount of fuel added to the fuel. Table 6.2.6-8 contains the projected refueling emission inventories for recreational vehicles.

Table 6.2.6-8
Projected Refueling Emissions from Recreational Vehicles [short tons]

Calendar Year	Snowmobiles	ATVs	Off-Highway Motorcycles
2000	1,814	928	368
2005	2,230	1,620	544
2010	2,596	1,185	684
2020	2,922	2,510	773
2030	3,120	2,532	840

Appendix to Chapter 6: ATV and Off-highway Motorcycle Usage Rates

This appendix presents the analyses used to determine the annual average usage rates for ATVs and off-highway motorcycles.

6A.1 ATV Usage

On October 5, 2001, EPA published proposed emission regulations for nonroad land-based recreational vehicles. These regulations covered snowmobiles, off-highway motorcycles, and all-terrain vehicles (ATVs). The Motorcycle Industry Council, Inc. (MIC) and the Specialty Vehicle Institute of America (SVIA) submitted comments suggesting that the EPA estimates for ATV usage had been substantially overestimated. They stated that our mileage estimate of 7,000 miles per year was too high and that based on some additional information that they had obtained, a more reasonable estimate was a lifetime average of 350 miles per year. As a result of these comments and the subsequent new information, EPA has revised it’s estimate of annual ATV usage.

Background

On November 20, 2000 EPA published a Final Finding of Contribution and Advance Notice of Proposed Rulemaking (ANPRM) for large nonroad spark-ignition engines and land-based recreational vehicles. In this process, we developed emission inventories for the various engine and vehicle categories covered by both these documents. EPA developed inventories using NONROAD model, which computes emission estimates for nonroad engines at selected geographic and temporal scales. The model incorporates data on emission rates, usage rates, and vehicle population to determine annual emission levels of various pollutants.
For recreational vehicles, and more specifically ATVs, data on emission rates and usage rates was extremely limited. We approached members of the ATV industry to provide us with any data that they had on emission and usage rates. Unfortunately, all of the emission data industry had for ATVs was collected on the J1088 steady state engine test cycle rather than the FTP transient vehicle test cycle that we proposed. Industry also indicated that they didn’t have any data on ATV usage rates. MIC provided survey data on off-highway motorcycle usage, but did not provide any information on ATV usage. Through our literature search, we ultimately found a study by the United States Consumer Product Safety Commission (CPSC) published in April of 1998 titled, “All-Terrain Vehicle Exposure, Injury, Death, and Risk Studies” that provided information on ATV usage. This study provided the basis for our estimate of ATV usage for the NPRM.

We did not receive any comments on our estimate of ATV usage during the comment period for the Final Finding and ANPRM . In fact, we did not receive any comments until after the Notice of Proposed Rulemaking (NPRM) was published in October of 2001.

ATV Usage in the ANPRM and NPRM

Because we received no comment or additional information for the ANPRM and NPRM, we determined that the CPSC study was the best source of information available. After converting hours of use to miles ridden, we estimated an annual average of 7,000 miles/year. A complete description of the modeling parameters for ATVs used in the NPRM is contained in an EPA memorandum entitled "Emission Modeling for Recreational Vehicles."[30]

New Information

Since the publication of the October 2001 NPRM, several new pieces of information on ATV usage have become available. These new sources consist of:

- Nationwide sources
  - ATV manufacturer warranty data
  - A Honda owner survey
  - ATV Industry Panel Survey (consisting of five ATV manufacturers)

- State studies on economic impact of ATV operation on their respective states
  - California[31]
  - Colorado[32]
  - Maine[33]
  - Michigan[34]
  - I. Utah[35]

- Instrumented ATV Usage Data (CE-CERT)
  - Speed information

Each of these sources is discussed in more detail below.

<u>Warranty Data</u>

One ATV manufacturer supplied ATV mileage and hour data from some its warranty claims submitted over a period of four years. The data was substantial and represented a good cross section of the country. The data is proprietary and was provided to us as confidential business information. This manufacturer does not have odometers or hour-meters on all of their ATV models, but provided data on those models equipped with an odometer or hour-meter, which happens to be only their utility models. Thus, there is no data for any of their sport models.

Intuitively, we were concerned about using data from warranty claims because of the possibility that usage data for machines that have been experiencing problems may not be reflective of how someone actually operates an ATV. Depending on the nature of the warranty claim, the ATV owner may decide to not operate their machine as much as they want because of a mechanical problem that doesn't allow the ATV to work or concern that the problem could be exacerbated by continued operation. Ultimately, because of the size of the data set, we felt we couldn't dismiss the data simply based on the fact that the data is from warranty claims. We did however have another concern with the data. The manufacturer indicated to us that they require mileage to be reported on the warranty claim form. However, discussions with several local dealers indicated something different. One dealer stated that the manufacturer had told them to record hours instead of mileage, so that they either didn't include hours or only casually added it when they remembered. Another dealer said that the manufacturer had indicated to them that neither input was important, since the warranty is based on time after purchase (e.g., six months) rather than usage and that they, therefore, entered data somewhat haphazardly, if at all. These inconsistencies raised concerns over the accuracy of the mileage and hour data. If dealerships don't pay close attention to what numbers they enter into the warranty claim forms, then the warranty data could be suspect.

To eliminate this concern and more in general as a means to provide a degree of validation to the data set used, we decided to only use data which contained both odometer and hour meter readings. This way we could compare the values and make sure that they appeared to be consistent with each other. Of the data points supplied, almost half of the data had only odometer readings, while the other half had only hour readings. There was, however, a smaller subset of data that included both types of data (approximately 3,000 data points). This data was further screened as discussed below.

Honda Study

Honda hired a contractor to perform a phone survey of Honda ATV owners to inquire as to how many total hours and miles were on their machines. The surveyor asked the owner if the odometer and hour meter on their ATV was functional. If so, they asked them to read the mileage and hour reading directly from their ATV. Honda only contacted people who had purchased utility models since they are the only ATV models Honda sells that are equipped with odometer and hour meters. The Honda survey does not contain data for sport models. Honda used the odometer and hour meter readings combined with the model year of each model to determine what the yearly mileage and hour usage was for each ATV in the survey. They had a sample size of 611 ATVs that were mostly distributed evenly and randomly across the country, thus the survey results appear to provide a national perspective.

The survey did not include any ATVs newer than 13 months or older than four years. Honda wanted data for ATVs older than 13 months because in order to determine the number of miles and hours ridden per year, they simply took the odometer or hour meter reading and divided it by the machines age. For example, a machine that had 2,000 miles and was two years old would average 1,000 miles per year. If they selected data from machines newer than a year old, they would have to extrapolate to at least a year to get the average yearly usage. They felt that extrapolating the data would be improper since it could either overestimate or underestimate the usage depending on how the owner rode their machine during the months involved. If the data was for a machine was only six months old, then the simplest way to extrapolate would be to double the mileage or hours from the first six months. There is no way of knowing whether the owner would have ridden more or less in the following six months, thus the concern with over- or underestimating the usage.

Industry Panel Survey

In 1997, five of the major ATV manufacturers conducted an industry panel survey to determine how well the survey information from the ATV exposure study performed by CPSC in the same year would correlate with their own independent, but similar survey. The purpose of the industry panel survey was to use a similar methodology and format as the CPSC study but to survey an independent random sample of ATV owners to replicate the CPSC survey . They aimed for the same approximate sample size gathered randomly from across the country. Relevant survey questions used phrasing almost identical to that used in the CPSC survey. The survey and data were provided to us on a confidential basis and cannot be shared here. However, it can be stated that the yearly hour usage results from the industry panel survey are very consistent with the CPSC study results.

State Studies

All of the state studies were done in 2000 or later and were not available at the time we originally developed our ATV usage estimates for the proposal, with the exception of the California study which was done in 1994. Three of the studies (Colorado, Maine, and Utah) were provided to us by MIC. The Michigan study was obtained by EPA after a literature search on ATV activity and usage. We were made aware of the California study through comments from the Blue Ribbon Coalition. The purpose of the state studies was to measure the economic impact of ATV and other recreational vehicle operation on the state economy. One of the results from the studies was an estimate of how often ATVs were used in the respective state for that particular year. The studies were based on user surveys that were typically mailed to registered ATV owners. Mileage estimates were typically based off a single question posed in the survey that asked the participant "How many miles did you ride your ATV in the past year?" All of the studies measured usage in miles per year. Maine also recorded information on hours per year. Average annual ATV usage from the state studies ranged from 320 mi/yr in Michigan to 1,270 mi/yr in Utah. It should be noted that according to the NONROAD model, these four states only represent approximately four percent of the total U.S. ATV population and only Michigan is in the top 20 states in ATV population.

The state studies were good for their intended purpose but since they weren't designed specifically to answer the questions at hand, they each have some shortcomings that limit their value to us. For example, all four states are cold climate states with cold winters and snow accumulation that may limit the amount of annual operation, especially compared to some of the warmer states that have higher ATV populations (e.g., Texas, Georgia, Tennessee, Alabama, etc.). The ATV industry has indicated that ATV operation is becoming very prevalent in agricultural use. Two of the states, Utah and Maine, are not large agricultural states, thus potentially resulting in a lower usage estimate than could be expected from a national study. All four of the state studies focused only on registered ATV owners. This has the potential for underestimating the number of miles ridden, since it does not provide a broad spectrum of all ATV riders in the respective state. In some states, registration is only required for use on public lands. Mileage estimates from three of the four studies were based on a single question inquiring about ATV use. There was no attempt made to verify with the respondent the accuracy of their estimate, as was done in the CPSC and Industry Panel studies. Four of the studies had discrepancies between their estimates of mileage and fuel usage. In almost each of the studies, the amount of fuel the respondents estimated they used for their ATV in one year would result in mileage results far higher than the actual mileage estimates provided by the respondents, creating a level of uncertainty about the viability of the mileage estimates. Finally, the California study combined data for ATVs with off-highway motorcycles, making it impossible to discern the mileage or fuel consumption for only ATVs.

We also obtained data from a separate report done by the State of California on ATV activity data collection. California hired the University of California, College of Engineering - Center for Environmental Research and Technology (CE-CERT) to instrument 41 ATVs and have the owners operate them in several California off-road parks and measure vehicle and engine speed.[36] This work was done to help California better estimate ATV in-use operation and emissions inventories within California. At this time, California has not completed their analysis of the data, nor have they started to develop any new modeling, so their work is unavailable as a source for ATV inventories. However, the CE-CERT draft report provides a summary of ATV activity work. They focused on measuring vehicle speed and fuel consumption.

ATV Usage Derivation Methodology for the Final Rulemaking

Criteria

In attempting to reconcile the results from the various data sets, we established three guiding criteria. The ideal data set would have all of these characteristics: 1) national scope; 2) “real” data (actual measurement readings as opposed to survey results based on recollection); and 3) a broad spectrum of ATV use (sport and utility operation). None of the existing data sets meet all three criteria. Therefore, we decided that it was important to select data sets that met two of the three criteria. Four of the data sets meet two of the above criteria. The CPSC and Industry Panel Survey data have a national scope and broad spectrum of ATV use. The warranty data and the Honda survey data are both real data that provide a national scope. The state studies, however, only provide a broad spectrum of use and many have a bias towards use on public lands. They do not provide a national scope, nor are they generally based on “real” data. Therefore, our methodology to determine ATV usage is based on the CPSC, Industry Panel Survey, warranty, and Honda data. The state studies were not used because they did not meet two of out three criteria, and as was briefly summarized above, had some shortcomings we could not resolve. Of the three criteria, we felt that data which provide a national scope was the most important, since it would remove any possible regional or state bias in ATV usage that could exist. For example, some states may have higher usage levels because of unique or appealing terrain, a large amount of public and private land available for riding on, an extended riding season due to warmer climate, or greater potential for agricultural, ranching, and hunting usage, that may not be reflected if we only use data from the four states that have performed studies on ATV usage.

Utility vs. Sport ATVs

Utility ATVs are designed for multiple purposes and are most often used for hunting and fishing, camping, yard work, farm work, as well as recreational trail riding. Sport ATVs are designed for aggressive recreational riding over rough terrain and closed courses, where higher speeds and performance are desired. According to Kawasaki, currently 75% of all ATV sales are for utility models and 25% are for sport models. Ideally, we would want the population percentage of sport and utility usage rather than sales, but this data is not available.

Hours vs. Miles

The NONROAD model uses miles per year of operation, rather than hours per year of operation, as one of the main inputs in calculating the inventory estimates for HC, CO, NOx, and PM emissions. Thus, to be consistent with the needs of the model, we were required to make sure all of the data used was in miles per year of operation. Only the Honda and warranty data had mileage data. However, all four data sets have hour data. In order to convert the hour data into mileage estimates, we had to multiply the hour values by an average ATV speed estimate.

Average Speed

Ideally, we would want to develop an estimate for the average ATV speed that includes both of the different types of models (utility and sport). Unfortunately, there wasn't a single data set that could be used to determine average speed for both types of models. The Honda and warranty data only included utility models. However, from these data sets we were able to determine average speed for a utility ATV, since the ATVs in these data sets were equipped with odometers and hour meters, which allowed us to calculate average speed. From this data we were able to determine that the average speed for utility ATVs is about 8 mi/hr.

None of the four data sets had information that would allow the calculation of average speed for sport ATV models. As discussed above, CE-CERT instrumented 41 ATVs and had the owners operate them in several California off-road parks and measure vehicle and engine speed. The off-road parks examined allowed operation over trails, desert, and sand dunes. Of the 41 instrumented ATVs, 36 were sport models and five were utility models. For the purposes of our analysis, we considered all 41 ATVs as indicative of sport operation, since the riding that occurred in these off-road parks was clearly recreational or sport, rather than utility usage. The average speed for all 41 ATVs was about 13 mi/hr.

Methodology

The data permitted us to develop a methodology that would determine fleet average miles per year by weighting separate mileage estimates for utility and sport ATVs based on average use, average speed and sales. The equation looks like this:

Utility ATVs *Sport ATVs*
(0.75)(hours/yr)(miles/hour) + (0.25)(hours/yr)(miles/hour) = Total miles/year for all ATVs

The 0.75 factor represents the percentage of total ATV sales that are for utility models, while the 0.25 factor represents the remaining percentage of sales which are for sport models. Population would have been preferable to sales, but that information was not available.

Utility ATV Estimates

To determine the mileage estimate for utility ATV models, we chose to use the data from the Honda and warranty data sets. We selected these two data sets because they both consisted entirely of data for utility ATVs. We merged both data sets and calculated the average hours per year of operation and average speed (mi/hr). Prior to merging the data sets we performed several quality checks of the data. First, we only used data that had both mileage and hour values. This was so we could calculate an average speed for utility ATVs. All of the Honda data had both values (approximately 605 data points). The warranty data had only a relatively small subset of data that contained both mileage and hours (approximately 3,000 data points). Next, we eliminated any of the warranty data that was for ATVs newer than 30 days and older than three years, consistent with MIC's analysis. We found that for the warranty data, there appeared to a significant number of data points that were duplicates (number of instances where same entry was made twice). Since some of these duplicates were for usage rates that were either very high or very low, we decided to remove all duplicates so that they would not bias the data. We also deleted any samples that had identical miles and hours figures, on the basis that these readings were probably mistakes, since it was unlikely that a rider would ride the exact same number of miles and hours per year (e.g., 500 mi/yr and 500 hr/yr). Finally, we deleted any data from both data sets that had an average speed greater than 25 mph, since information provided by the American Motorcycle Association (AMA) on ATV race track statistics indicates that for professional ATV racers, the average speed is 24 mph. Therefore, it did not seem reasonable to include data for speeds in excess of those achieved by professional ATV racers.

The combined sample size of the merged data set was 2,531. The average speed for utility ATVs from the merged data set was 8 miles per hour and the average hours of use was 151 hours per year. Our hours per year estimate for utility ATV use is corroborated by the CPSC study and information from MIC. A discussion of nonrecreational or utility use in the CPSC study states "..high use nonrecreational (utility) drivers tend to be older (36 years and up).." (See page 14 of CPSC study). MIC has stated that the average age of individuals buying utility ATV models is between 40 and 50 years old. The CPSC study indicates that for riders in the 40 to 50 year old age range, the average hourly usage was 158 hours per year (see page 27 of CPSC study).

Sport ATV Estimates

To determine the mileage estimate for sport ATV models, we used the data from the CPSC and Industry Panel Survey data sets. Since we were unable to determine average speed from these data sets, we used the average speed of 13 mph derived from the CE-CERT data for the 41 instrumented ATVs.

The CPSC and Industry Panel studies were done in 1997. Based on information from these studies, between 50%-75% of the ATVs in both studies were from the 1980-1995 model years. Between 1980 and 1990, sport ATVs were the predominant ATVs sold in the U.S. Although their sales were starting to decline in favor of utility models, sport models were still responsible for approximately 50% of all ATV sales from 1990 through 1995 and were the majority of the ATV population. Therefore, both of these studies are most likely biased towards operation with sport ATV models and should, therefore, be most representative of sport ATV operation.

The annual riding hours from both data sets was determined by multiplying results of three survey questions concerning riding patterns: (1) the number of months during which ATVs were ridden during the previous year, (2) the number of days of riding in an average month, and (3) the number of hours of riding in an average day. The total hours per year were then calculated from the following equation.

$$\frac{hours}{year} = \frac{months}{year} \cdot \frac{days}{month} \cdot \frac{hours}{day}$$

We averaged annual rider hours from the CPSC and industry panel surveys, due to their similarities in approach and results. In deriving average estimates from each, we reviewed results for the questions used in the calculation, and modified some results that we considered implausible. Specifically, for those records where the respondent claimed more than 10 hours of use on an average day of riding, we limited daily usage at a maximum of 10 hours. The resulting annual average usage rate was 216 hours per year.

In relation to their study objectives, the CPSC and Industry Panel studies both presented usage results for the average rider, rather than for the average ATV. In other words, results are presented as hours/rider/year, rather than hours/ATV/year. For the NPRM, we attempted to correct hours/rider to hours/ATV using the ratio of the national rider population to the total ATV population, as follows[hh]:

[hh] In the NPRM analysis, we also applied an adjustment to subtract "inactive" riders from the total rider population. In subsequent correspondence, the author of the CPSC study indicated that such an adjustment was unnecessary, as the national population estimated in the report was intended to represent only "active riders," defined as riders who had reported using their ATVs in the previous year. Thus, the "inactive rider" adjustment is not presented here.

$$\frac{hours}{ATV \cdot year} = \frac{hours}{rider \cdot year} \cdot \left(\frac{national\ rider\ \ population\ (riders)}{national\ \ ATV\ \ population\ (ATVs)} \right)$$

In this analysis, we recalculated the average usage rate (i.e., hours per rider-year) using a data set of results for individual respondents, which enabled review of individual responses, as mentioned above. To be consistent with this approach, it would be appropriate to recalculate the "correction" using individual responses, as opposed to gross national averages, as in the equation above. However, several pieces of data needed for this calculation were unavailable, specifically, the numbers of riders and ATVs in each respondent household. Accordingly, for purposes of this analysis, we assumed that rider hours as reported in the CPSC and industry panel studies were equivalent to ATV operating hours.

Mileage Estimate

By plugging in the above values derived for utility and sport ATVs average hourly operation and average speed into the equation discussed above, we were able to determine a mileage estimate for ATVs of 1,608 mile per year.

Utility ATVs *Sport ATVs*

(0.75)(151 hr/yr)(8 mi/hr) + (0.25)(216 hr/yr)(13 mi/hr) = **1,608 mi/yr**

Conclusion

It is informative to consider the outcome from our methodology to the results of the studies we did not use, or the alternative application of some of the individual studies that we did use. The state studies do not have the strength of the national studies and were not used in our analysis. The state studies represent only 4% of U.S. ATV registrations and all four states are cold weather states that may not reflect winter use in warmer states. State methodologies give results of mixed value. For example, two state studies had low mileage estimates: Michigan had an estimate of 320 mi/yr and Colorado had an estimate of 610 mi/yr, while Utah had an estimate of 1,270 mi/yr which is closer to our estimate. Maine had even more mixed results. Their estimate ranged from 535 mi/yr to 1,646 mi/yr depending on which methodology they used to determine mileage, the direct question or the multiple questions. The Honda survey data had an estimate of 560 mi/yr. The warranty data had an estimate of 1,340 mi/yr. Both of these data sets included only utility ATVs. The CPSC and Industry Panel studies had hour estimates of approximately 250 hr/yr, which depending on the average speed used, can have a mileage range of 1,900 mi/yr (for the average utility ATV speed of 8 mph) to 3,150 mi/yr (for the average sport ATV speed of 13 mph). Therefore, we believe that our estimate of 1,608 miles per year is reasonable and the best estimate considering all of the available data.

There is currently no data set which alone can be characterized as providing the best estimate of ATV annual usage. All of the available data sets have some shortcomings. Looking across all of the studies considered in the analysis yields mileage estimates from 320 mi/yr to

3,150 mi/yr. It is impossible to reconcile all eight data sets and it is not analytically appropriate to average all of the data sets because they aren't all of equal strength or value. The methodology we've developed is the best way to reconcile broadly ranging data of the highest value.

6A.2 Off-Highway Motorcycle Usage

On October 5, 2001, EPA published proposed emission regulations for nonroad land-based recreational vehicles. These regulations covered snowmobiles, off-highway motorcycles, and all-terrain vehicles (ATVs). The Motorcycle Industry Council, Inc. (MIC) submitted comments suggesting that the EPA estimates for off-highway motorcycle (OHMC) usage had been overestimated. They stated that our mileage estimate of 2,400 miles per year was too high and that based on some additional information that they had obtained, a more reasonable estimate was a lifetime average of 600 miles per year. As a result of these comments and the subsequent new information, EPA has revised it's estimate of annual OHMC usage.

Background

On November 20, 2000 EPA published a Final Finding of Contribution and Advance Notice of Proposed Rulemaking (ANPRM) for large nonroad spark-ignition engines and land-based recreational vehicles. We had to develop emission inventories for the various engine and vehicle categories covered by both of these documents. EPA has developed an emissions model named NONROAD, which computes nationwide emission levels for nonroad engines. The model incorporates data on emission rates, usage rates, and vehicle population to determine annual emission levels of various pollutants. For recreational vehicles, and more specifically OHMCs, data on emission rates and usage rates was extremely limited. Because of the lack of data, we initially grouped OHMCs and ATVs together. However, as we performed literature searches and attempted to uncover additional data on OHMC emissions and activity, it became apparent that OHMCs and ATVs were used differently and unique emission rates, usage rates, and populations should be established. We approached members of the OHMC industry to provide us with any data that they had on emission and usage rates. MIC provided survey data on off-highway motorcycle usage. We also found a study done in 1999 by the Oak Ridge National Laboratory (ORNL) titled, "Fuel Used for Off-Road Recreation: A Reassessment of the Fuel Use Model" that provided information on OHMC usage. We examined these two studies to develop our estimate of OHMC usage for the November 2000, ANPRM and the October 2001, NPRM.

Off-Highway Motorcycle Usage as developed for ANPRM and NPRM

For OHMC, there were two sources of information on activity or usage rates that we examined. The first source was information provided by the motorcycle industry. MIC periodically conducts surveys to obtain diverse information on motorcycle facts, such as number of motorcycles per rider, types and makes of bikes, on-road or off-road, bike education, etc. The survey also gathers information on motorcycle usage. MIC used two methods of estimating OHMC usage from the survey results. Method one was based on the results of a single question that asks the respondent how many miles they rode their OHMC in the last year. Method two is based on the compilation of the response from three questions: 1) how many months do you ride per year, 2) how many days do you ride per month, and 3) how many miles do ride per day. The MIC estimate for method one was 222 miles per year and 1,260 miles per year for method two. MIC suggested that method one was the more appropriate estimate because method two may compound any error that exists in the results of each of the three questions. We had concerns with the results of the MIC survey because the values for method one and two were so dramatically different.

The second source of information was the 1999 ORNL study. In their study, ORNL estimated total average fuel usage for off-highway motorcycles. They provided a medium estimate of average fuel usage for OHMCs of 59 gallons per year. Data from California and some older SwRI work on OHMC emission testing suggested that the average fuel economy for OHMCs was approximately 50 miles per gallon (mpg), as tested over the FTP (a relatively non-aggressive driving cycle when compared to some OHMC uses). We determined that this estimate could be too high for actual in-use off-road operation, so we derived from the data an estimate of 40 mpg. By multiplying the average fuel used per year by the average fuel economy, we arrived at an estimate of approximately 2,400 miles per year.

OHMC Usage = (59 gallons/year)(40 miles/gallon) = 2,400 miles/year

We also found another ORNL study published in 1994 where MIC also estimated average fuel usage in their survey with a resulting mean value of 214 gallons per year.[37] If we used our estimate of 40 mpg, 214 gallons per year would yield 8,560 miles. Because of the large discrepancies in the three MIC based values, we chose to use the estimate of 2,400 miles per year.

New Information on Off-Highway Motorcycle Usage

Since the publication of the NPRM in October 2001, several new pieces of information on OHMC usage have become available. These new sources consist of state studies from California[38], Michigan[39], Oregon[40], and Utah[41] on OHMC usage (the California and Oregon studies were used in both of the ORNL studies). These studies present information on the number of miles OHMC's are ridden per year and/or the number of gallons of fuel used per year riding OHMCs. We also received information from the American Motorcycle Association (AMA) on rider surveys which attempt to quantify the number of miles ridden per year by the average OHMC rider.

Finally, we obtained new information on the fuel consumption of OHMCs. The state of California hired the University of California, College of Engineering - Center for Environmental Research and Technology (CE-CERT) to instrument a number of OHMCs that were operated in several California off-road parks and motocross tracks and measure vehicle and engine speed.[42] This work was done to help California better estimate OHMC in-use operation and emissions inventories within California. At this time, California has not completed their analysis of the data, nor have they started to develop any new modeling, so their work is unavailable as a source for OHMC emissions inventories. However, they have shared with us data on fuel consumption from the OHMC testing. We also had updated emission and fuel economy test results for 10 OHMCs tested by EPA over the FTP.

State Studies

All four of the state studies included estimates of average yearly total fuel consumption for OHMCs, but only the Michigan and Utah studies also provided estimates for average yearly mileage for OHMCs. The average yearly total fuel consumption for the four studies ranges from 32 gallons per year for Michigan to 89 gallons per year for Oregon. The average for the four studies is 57 gallons per year. Table 6A.2-1 lists the average yearly total fuel consumption for the four studies. The two states that provided estimates for average yearly mileage were Michigan and Utah. Michigan listed a yearly mileage of 494 miles per year, while Utah had a value more than twice that with 1,067 miles per year.

Table 6A.2-1
Off-Highway Motorcycle Average Gallons of Fuel Consumed and Mileage Ridden Per Year

State Study	Average Gallons Per Year	Average Mileage Per Year
Michigan	32	494
California	44	n/a
Utah	62	1,067
Oregon	89	n/a
Average	57	781

AMA Survey

AMA presented survey results from 1994, 1996, 1998, & 2000 on how many miles AMA members rode OHMCs in each of these years. The data indicates a trend toward increased mileage each year. The survey was based on a mailing to AMA members listing questions as to riding habits. AMA broke the survey results into six bins based on miles ridden in the last 12 months:

- 0 - 499 mi/yr
- 500 - 999 mi/yr
- 1,000 - 1,499 mi/yr
- 1,500 - 1,999 mi/yr
- 2,000 or more
- No answer

They determined the total number of miles ridden by taking the median value of each bin and multiplying it by the number of responses in that bin. They did this for each bin. They then summed the results for all of the bins. The summation was then divided by the total number of responses. For the bin categorizing responses of 2,000 miles or more, rather than using the median, as with the other bins, they capped the mileage at 2,000 miles. This is problematic since 19% of all responses fell into this bin. By capping the values in this bin at 2,000 miles, the estimate for this bin is too low. This would indicate that their estimate for average total OHMC miles ridden per year is also probably too low. They estimated that in 2000, the average AMA member rode 1,158 miles.

New Fuel Economy Estimates

We have tested nine OHMCs at our National Vehicle and Fuel Emissions Laboratory (NVFEL) in Ann Arbor, Michigan. We also have the fuel economy results from a test done by California on a 1999 Yamaha WR400. All of the tests are over the transient highway motorcycle FTP test cycle. Table 6A.2-2 lists the results for the 4-stroke OHMCs. Table 6A.2-3 lists the results for the 2-stroke OHMCs.

Table 6A.2-2
FTP Fuel Economy for 4-Stroke Off-Highway Motorcycles

Manufacturer	Model	Model Year	Fuel Economy (mpg)
Yamaha	WR250F	2001	39
Yamaha	WR400	1999	55
Husaberg	FE501	2001	53
KTM	400EXC	2001	54
Average			50

Table 6A.2-3
FTP Fuel Economy for 2-Stroke Off-Highway Motorcycles

Manufacturer	Model	Model Year	Fuel Economy (mpg)
KTM	125 SX	2001	21
KTM	125 SX	2001	31
KTM	200 EXC	2001	22
KTM	250 SX	2001	18
KTM	250 EXC	2001	20
KTM	300 EXC	2001	21
Average			22

The CE-CERT data developed for the State of California was based on actual in-use fuel consumption measurements made on numerous OHMCs operated by the owners at several off-road motorcycle parks and a motocross track. The parks consisted of trail riding, desert riding, sand dune riding, and a mixture of all three. These riding scenarios could be considered closer to worst case conditions that may not be reflective of average in-use operation nationally. The results were 24 mpg for the 2-stroke machines and 27 mpg for the 4-stroke machines.

Off-Highway Motorcycle Usage Derivation Methodology for the Final Rule

Based on the new information we have received, there are two approaches we could choose to estimate annual average OHMC usage. The first would be to base the estimate on the mileage estimates presented in the Michigan, Utah, and AMA studies. The second would be to use the same methodology we used for the ANPRM and NPRM, which uses total fuel consumption from four state studies and fuel economy measurements from the California survey and EPA FTP results to estimate mileage.

The first approach appears to be limited, since the AMA study under predicts the annual mileage and since we do not have the raw data, there doesn't appear to be a method to upgrade the estimate that wouldn't be somewhat arbitrary. This leaves only the mileage per year estimates from the two state studies. There were two concerns with using the mileage estimates from the two state studies. First of all, many OHMC models are not equipped with odometers, which would make it difficult for participants responding to the state surveys to recall how many miles they actually rode. Secondly, the average gallons per year and miles ridden per year reported result in average fuel economy estimates of 15 and 17 miles per gallon. These values are considerably lower than values from the CE-CERT and EPA testing. This means that either the gallons per year estimates are high or the mileage per year estimates are low. Since we had more sources for total fuel consumption and fuel economy values based on emissions test results and actual in-use operation, it appears to be more appropriate to use the second methodology (which is based on fuel consumption), rather than the first methodology (which is based on mileage) with only two questionable data points.

The equation for estimating average annual OHMC mileage based on fuel consumption is:

OHMC Usage in miles per year = (gallons/year)(miles/gallon)

The gallons per year value is based on the average of the four state studies which is 57 gallons per year. We are not including the ORNL study directly. The ORNL study consisted of data that they had obtained from the California and Oregon studies and the MIC survey. ORNL agrees with us that they thought the MIC survey information was of limited value for the same reasons that we pointed put. To address their concern over using this data, they decided to give each of the three studies a weighted value, with the MIC and Oregon studies having lower weightings than the California study. We decided that it was more prudent to just use the California and Oregon studies in combination with the other two new state studies from Utah and Michigan, rather than include the MIC data.

For the fuel economy we had FTP results from EPA testing and in-use results from CE-CERT. Since there is no way of knowing which of these set of values are the most correct (in-use data was for relatively extreme operation) we chose to take the average of the two data sets. However, before we did this, we decided to determine the overall fuel economy for each data set based on the weighted impact of the two different types of engines, 2-stroke and 4-stroke. The current break-down of 2-stroke and 4-stroke engines in OHMCs is 67% for 2-stroke engines and 33% for 4-stroke engines. Thus, we used the following equation to estimate fuel economy:

Fuel Economy (FE) = (0.67)(2-stroke FE (mpg)) + (0.33)(4-stroke FE (mpg))

For the EPA FTP testing, the average weighted fuel economy results are the following:

FE = (0.67)(22 mpg) + (0.33)(50 mpg) = 31 mpg

For the CE-CERT in-use measurements, the average weighted fuel economy results are the following:

FE = (0.67)(24 mpg) + (0.33)(27 mpg) = 25 mpg

The average of these two data sets is 28 mpg. Combining the value of 28 mpg with the fuel consumption value of 57 gallons per year results in an average of 1,600 miles per year for OHMCs.

OHMC Usage = (57 gallons/year)(28 miles/gallon) = 1,600 miles/year

Chapter 6 References

1. “Evaporative Emission Calculations for Recreational and Large SI Vehicles,” Memorandum from Mike Samulski, U.S. EPA to Docket A-2000-01, September 6, 2002, Document IV-B-38.

2. API Publication No. 4278, “Summary and Analysis of Data from Gasoline Temperature Survey Conducted at Service Stations by American Petroleum Institute,” Prepared by Radian Corporation for American Petroleum Institute, November 11, 1976, Docket A-2000-01, Document II-A-16.

3. Nulman, M., Olejnik, A., Samus, M., Fead, E., Rossi, G., “Fuel Permeation Performance of Polymeric Materials,” SAE Paper 2001-01-1999, 2001, Docket A-2000-01, Document No. IV-A-23.

4. Lockhart, M., Nulman, M, Rossi, G., “Estimating Real Time Diurnal Permeation from Constant Temperature Measurements,” SAE Paper 2001-01-0730, 2001, Docket A-2000-01, Document No. IV-A-21.

5. D. T. Wade, “Factors Influencing Vehicle Evaporative Emissions,” SAE Paper 670126, 1967, Docket A-2000-01, Document II-A-59.

6. Wade et. al., “Mathematical Expressions Relating Evaporative Emissions from Motor Vehicles without Evaporative Loss-Control Devices to Gasoline Volatility,” SAE Paper 72070, 1972, Docket A-2000-01, Document II-A-58.

7. S. Raghuma Reddy, “Prediction of Fuel Vapor Generation from a Vehicle Fuel Tank as a Function of Fuel RVP and Temperature,” SAE Paper 892089, 1989, Docket A-2000-01, Document II-A-61.

8. S. Raghuma Reddy, “Prediction of Fuel Vapor Generation from a Vehicle Fuel Tank as a Function of Fuel RVP and Temperature,” SAE Paper 892089, 1989, Docket A-2000-01, Document II-A-61.

9. “Final Regulatory Impact Analysis: Refueling Emission Regulations for Light Duty Vehicles and Trucks and Heavy Duty Vehicles,” U.S. EPA, January 1994, Docket A-2000-01, Document II-A-79.

10. Pagán, Jaime, “Investigation on Crankcase Emissions from a Heavy-Duty Diesel Engine,” U.S. Environmental Protection Agency, March, 1997, Docket A-2000-01, Document II-A-70.

11.“The Role of Propane in the Fork Lift/Industrial Truck Market: A Study of its Status, Threats, and Opportunities,” Robert E. Myers for the National Propane Gas Association, December 1996, Docket A-2000-01, Document II-A-86.

12.“Three-Way Catalyst Technology for Off-Road Equipment Powered by Gasoline and LPG Engines—Final Report” Jeff J. White, et al, Southwest Research Institute, SwRI 8778, April 1999, p. 45, Docket A-2000-01, Document II-A-08.

13.“Revisions to the June 2000 Release of NONROAD to Reflect New Information and Analysis on Marine and Industrial Engines,” EPA memorandum from Mike Samulski to Docket A-98-01, November 2, 2000, Docket A-2000-01, Document II-B-08.

14.“Regulatory Analysis and Environmental Impact of Final Emission Regulations for 1984 and Later Model Year Heavy Duty Engines,” U.S. EPA, December 1979, p. 189, Docket A-2000-01, Document II-A-71.

15. “Transient Adjustment Factors for Large SI Engines,” EPA memorandum from Alan Stout to Docket A-2000-01, September 27, 2001, Docket A-2000-01, Document II-B-29.

16. “Measurement of Evaporative Emissions from Off-Road Equipment,” prepared for South Coast Air Quality Management District by Southwest Research, November 1998, Docket A-2000-01, Document II-A-10.

17. Emission Modeling for Recreational Vehicles,” EPA memorandum from Linc Wehrly to Docket A-98-01, November 13, 2000, Docket A-2000-01, Document II-B-19.

18. “Median Life of Snowmobiles,” note from Phil Carlson, EPA to Ed Klim, ISMA, May 10, 2002, Docket A-2000-01, Document IV-B-28.

19. “Updated Snowmobile Sales Projections from National Economic Research Associates,”, EPA memo from Phil Carlson to Docket A-2000-01, August 1, 2002, Docket A-2000-01, Document IV-B-27.

20. “Updated Population Growth Projections for Snowmobiles, ATVs, and OHMCs,” EPA memo from Phil Carlson to Docket A-2000-01, August 7, 2002, Document IV-B-29.

21. “Updated Emission Factors for Snowmobiles, ATVs, and OHMCs,” EPA memo from Phil Carlson to Docket A-2000-01, August 8, 2002, Document IV-B-26.

22. Emission Modeling for Recreational Vehicles,” EPA memorandum from Linc Wehrly to Docket A-98-01, November 13, 2000, Docket A-2000-01, Document II-B-19.

23. “Estimate for All-Terrain Vehicle Annual Usage,” EPA memo from Linc Wehrly to Docket A-2000-01, September 6, 2002, Document IV-B-35.

24. “Updated Population Growth Projections for Snowmobiles, ATVs, and OHMCs,” EPA memo from Phil Carlson to Docket A-2000-01, August 7, 2002, IV-B-29.

25. “Updated Emission Factors for Snowmobiles, ATVs, and OHMCs,” EPA memo from Phil Carlson to Docket A-2000-01, August 8, 2002, Document IV-B-26.

26. “Estimate for Off-Highway Motorcycle Annual Usage,” EPA memo from Linc Wehrly to Docket A-2000-01, August 26, 2002, Document IV-B-36.

27. “Revised Median Life for Off-Highway Motorcycles,” EPA memo from Phil Carlson to Docket A-2000-01, August 6, 2002, Document IV-B-30.

28. “Updated Population Growth Projections for Snowmobiles, ATVs, and OHMCs,” EPA memo from Phil Carlson to Docket A-2000-01, August 7, 2002, Document IV-B-29.

29. “Updated Emission Factors for Snowmobiles, ATVs, and OHMCs,” EPA memo from Phil Carlson to Docket A-2000-01, August 8, 2002, Document IV-B-26.

30. “Emission Modeling for Recreational Vehicles,” EPA memorandum from Linc Wehrly to Docket A-98-01, November 13, 2000, Docket A-2000-01, Document II-B-19.

31. “1993 statewide Off-Highway Vehicle User Survey Analysis,” Prepared for the California Department of Parks and Recreation, Off-Highway Vehicle Recreation Division by California State University.

32. “ Economic Contribution of Off-Highway Vehicle Use in Colorado,” Prepared for the Colorado Off-Highway Vehicle Coalition by Hazen and Sawyer, July 2001 (submitted as an attachment to the Motorcycle Industry Council’s comments, document IV-D-214).

33. “Gasoline Consumption Attributable to ATVs in Maine,” Margaret Chase Smith Center for Public Policy, The University of Maine, Jonathon Rubin, Suzanne K. Hart, and Charles Morris, June 2001 (submitted as an attachment to the Motorcycle Industry Council’s comments, document IV-D-214).

34. “Michigan Licensed Off-Road Vehicle Use and Users: 1998-1999,” Department of Park, Recreation and Tourism Resources, Michigan State University, October 25, 2000

35. “Off-Highway Vehicle Uses and Owner Preferences in Utah,” Institute for Outdoor Recreation and Tourism, Department of Forestry Resources, Utah State University, July 22, 2001 (submitted as an attachment to the Motorcycle Industry Council’s comments, document IV-D-214).

36. “Off-Highway Motorcycle/All-Terrain Vehicle Activity-Data Collection; and Personal Watercraft Activity-Data Collection; Test Cycle Development and Emissions Test,” Prepared for California Air Resource Board by Thomas Durbin, Matthew R. Smith, Ryan D. Wilson, and Ted Younglove of College of Engineering - Center for Environmental Research and Technology, July 2002.

37. “Fuel Used for Off-Highway Recreation,” Patricia Hu, David Trumble, and An Lu, prepared by Oak Ridge National Laboratory for Federal Highway Administration, July 1994 (ORNL-6794).

38. "A Study To Determine Fuel Tax Attributable To Off-Highway and Street Licensed Vehicles Used For Recreation Off-Highway," prepared for the California Department of Transportation In Cooperation with the Department of Parks and Recreation, by Tyler and Associates, November 1990.

39. "Michigan Licensed Off-Road Vehicle Use and Users: 1998-1999," Department of Park, Recreation and Tourism Resources, Michigan State University, October 25, 2000.

40. "Fuel Used for Off-Highway Recreation," Patricia Hu, David Trumble, and An Lu, prepared by Oak Ridge National Laboratory for Federal Highway Administration, July 1994 (ORNL-6794).

41. "Off-Highway Vehicle Uses and Owner Preferences in Utah," Institute for Outdoor Recreation and Tourism, Department of Forestry Resources, Utah State University, July 22, 2001 (submitted as an attachment to the Motorcycle Industry Council's comments, document IV-D-214).

42. "Off-Highway Motorcycle/All-Terrain Vehicle Activity-Data Collection; and Personal Watercraft Activity-Data Collection; Test Cycle Development and Emissions Test," Prepared for California Air Resource Board by Thomas Durbin, Matthew R. Smith, Ryan D. Wilson, and Ted Younglove of College of Engineering - Center for Environmental Research and Technology, July 2002.

Chapter 7: Cost Per Ton

7.1 Cost Per Ton by Engine Type

7.1.1 Introduction

This chapter presents our estimate of the cost per ton of the various standards contained in this rule. The analysis relies on the costs estimates presented in Chapter 5 and the estimated lifetime emissions reductions using the information presented in Chapter 6. The chapter also presents a summary of the cost per ton of other recent EPA mobile source rulemakings for comparison purposes. Finally, this chapter presents the estimated costs and emission reductions as incurred over the first twenty years after the standards are implemented.

In calculating net present values that were used in our cost-per-ton estimates, we used a discount rate of 7 percent, consistent with the 7 percent rate reflected in the cost-per-ton analyses for other recent mobile source programs. OMB Circular A-94 requires us to generate benefit and cost estimates reflecting a 7 percent rate. Using the 7 percent rate allows us to make direct comparisons of cost-per-ton estimates with estimates for other, recently adopted, mobile source programs.

However, we consider that the cost and cost-per-ton estimates for future proposed mobile source programs could reflect a 3 percent rate. The 3 percent rate is in the 2 to 3 percent range recommended by the Science Advisory Board's Environmental Economics Advisory Committee for use in EPA social benefit-cost analyses, a recommendation incorporated in EPA's new *Guidelines for Preparing Economic Analyses (November 2000).* Therefore, we have also calculated the overall cost-effectiveness of today's rule based on a 3 percent rate to facilitate comparison of the cost-per-ton of this rule with future proposed rules which might use the 3 percent rate. The results using both a 3 percent and 7 percent discount rate are provided in this chapter.

7.1.2 Compression-Ignition Recreational Marine

As described in Chapter 5, several of the anticipated engine technologies will result in improvements in engine performance that go beyond emission control. While the cost estimates described in Chapter 5 do not take into account the observed value of performance improvements, these non-emission benefits should be taken into account in the calculation of cost-effectiveness. We believe that an equal weighting of emission and non-emission benefits is justified for those technologies which clearly have substantial non-emission benefits, namely electronic controls, fuel injection changes, turbocharging, and aftercooling for diesel engines and upgrading to electronic fuel injection for gasoline engines. For some or all of these technologies, a greater value for the non-emission benefits could likely be justified. This has the effect of halving the cost for those technologies in the cost-per-ton calculation. The cost-per-ton values in this chapter are based on this calculation methodology.

Although the rule will also result in PM reductions, we apply the total cost to the ozone forming gases (HC and NOx) presented in Chapter 6 for these calculations. The estimated per vessel costs presented in Chapter 5 change over time, with reduced costs in the long term. We have estimated both a near-term and long-term cost per ton as presented in Table 7.1-1 assuming a 7 percent discount rate. Table 7.1-2 presents the cost per tons results assuming a 3 percent discount rate..

Table 7.1-1
Estimated CI Recreational Marine Cost Per Ton of HC + NOx Reduced
(7 percent discount rate)

	Total Cost per Vessel (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vessel Cost ($/ton)
100 kW near-term	$231	0.24	$954
100 kW long-term	$141		$583
400 kW near-term	$396	0.97	$409
400 kW long-term	$175		$181
750 kW near-term	$1,118	1.32	$844
750 kW long-term	$374		$282
Composite near-term	$291	0.44	$669
Composite long-term	$155		$356

Table 7.1-2
Estimated CI Recreational Marine Cost Per Ton of HC + NOx Reduced
(3 percent discount rate)

	Total Cost per Vessel (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vessel Cost ($/ton)
100 kW near-term	$231	0.33	$703
100 kW long-term	$141		$429
400 kW near-term	$396	1.31	$301
400 kW long-term	$175		$133
750 kW near-term	$1,118	1.69	$661
750 kW long-term	$374		$221
Composite near-term	$291	0.59	$495
Composite long-term	$155		$263

7.1.3 Large Industrial SI Equipment

This section provides our estimate of the cost per ton of emissions reduced for large SI engines >19 kW. We have calculated cost per ton on the basis of exhaust HC plus NOx for gasoline, LPG and CNG engines and evaporative HC for gasoline engines. The analysis relies on the costs estimates in presented in Chapter 5 and the estimated net present value of the per vehicle lifetime emissions reductions (tons) presented in Chapter 6.

For the exhaust emission standards, the estimated per vehicle costs presented in Chapter 5 change over time, with reduced costs in the long term. We have estimated both a near-term and long-term cost per ton. In addition, we have estimated the cost per ton both with and without estimated fuel/maintenance savings. We have estimated the cost per ton for both the Phase 1 and Phase 2 standards, with the Phase 2 estimates incremental to Phase 1. The results of the cost per ton analysis for exhaust emission controls are presented in Tables 7.1.3-1 through 7.1.3-3 for gasoline, LPG and CNG engines assuming a 7 percent discount rate. The results of the cost-per-ton analysis for exhaust emission controls using a 3 percent discount rate follow in Tables 7.1.3-4 through 7.1.3-6.

Table 7.1-3
Estimated Large SI Gasoline Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(7 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$802	($3,247)	1.6	$496	($1,514)
Phase 1 long-term	$487			$301	($1,708)
Phase 2 near-term	$60	-	0.3	$175	-
Phase 2 long-term	$14			$41	-

Table 7.1-4
Estimated Large SI LPG Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(7 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$552	($4,557)	3.5	$158	($1,146)
Phase 1 long-term	$340			$97	($1,206)
Phase 2 near-term	$53	-	1.0	$56	-
Phase 2 long-term	$14			$15	-

Table 7.1-5
Estimated Large SI CNG Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(7 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions* (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$552	($1,648)	3.6	$153	($304)
Phase 1 long-term	$340			$94	($363)
Phase 2 near-term	$53	-	0.9	$61	-
Phase 2 long-term	$14			$16	-

* The reductions are calculated on the basis of NMHC+NOx for CNG engines only.

Table 7.1-6
Estimated Large SI Gasoline Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(3 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$802	($3,926)	2.0	$409	($1,573)
Phase 1 long-term	$487			$248	($1,733)
Phase 2 near-term	$60	-	0.4	$143	-
Phase 2 long-term	$14			$33	-

Table 7.1-7
Estimated Large SI LPG Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(3 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$552	($5,492)	4.2	$131	($1,162)
Phase 1 long-term	$340			$81	($1,212)
Phase 2 near-term	$53	-	1.2	$46	-
Phase 2 long-term	$14			$12	-

Table 7.1-8
Estimated Large SI CNG Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(3 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions* (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$552	($2,005)	4.4	$125	($321)
Phase 1 long-term	$340			$77	($369)
Phase 2 near-term	$53	-	1.1	$49	-
Phase 2 long-term	$14			$13	-

* The reductions are calculated on the basis of NMHC+NOx for CNG engines only.

For the evaporative emission standards, the estimated per vehicle costs are presented in

Chapter 5. We have estimated the cost per ton both with and without the estimated fuel savings which occur as evaporative emissions are reduced. The results of the cost per ton analysis for evaporative emission controls for gasoline large SI engines >19 kW are presented in Table 7.1-9 based on both a 7 percent and 3 percent discount rate.

Table 7.1-9
Estimated Large SI Gasoline Engine >19 kW Cost Per Ton of Evaporative HC Reduced

Discount Rate	Total Cost per Vehicle (NPV)	Lifetime Fuel Cost per Vehicle (NPV)	Lifetime Evaporative HC Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
7%	$13	($56)	0.16	$84	($279)
3%	$13	($69)	0.19	$68	($295)

7.1.4 Recreational Vehicle Exhaust Emissions

This section provides our estimate of the cost per ton of exhaust emissions reduced for recreational vehicles. We have calculated cost per ton on the basis of HC plus NOx for off-road motorcycles and ATVs, and both HC and CO for snowmobiles. For snowmobiles, we have spread costs evenly over HC and CO reductions for purposes of calculating cost per ton. If reductions in other pollutants were included, the cost per ton estimates would be lower. The analysis relies on the per vehicle costs estimated in Chapter 5 and the estimated net present value of the per vehicle lifetime emissions reductions (tons) presented in Chapter 6. These cost per ton estimates do not include permeation control which is calculated separately for recreational vehicles, below.

The estimated per vehicle costs presented in Chapter 5 change over time, with reduced costs in the long term. We have estimated both a near-term and long-term cost per ton. In addition, we have estimated cost per ton both with and without estimated fuel savings. For snowmobiles, we have estimated the cost per ton for all three phases of standard incremental to the previous standards. The results of the analysis using the 7 percent discount rate are presented in Tables 7.1-10 through Table 7.1-12. The results using the 3 percent discount rate follow in Tables 7.1-13 through 7.1-15.

Table 7.1-10
Estimated Snowmobile Average Cost Per Ton of HC and CO Reduced
(7 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)		Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)		Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)	
			HC	CO	HC	CO	HC	CO
Phase 1 near-term	$73	($57)	0.40	1.02	$90	$40	$20	$10
Phase 1 long-term	$40				$50	$20	($20)	($10)
Phase 2 near-term	$131	($286)	0.10	n/a	$1,370	n/a	($1,610)	n/a
Phase 2 long-term	$77				$810	n/a	($2,190)	n/a
Phase 3 near-term	$89	($191)	n/a	0.25	n/a	$360	n/a	($410)
Phase 3 long-term	$54				n/a	$220	n/a	($550)

Table 7.1-11
Estimated ATV Average Cost Per Ton of HC + NOx Reduced
(7 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
near-term	$84	($24)	0.21	$400	$290
long-term	$42			$200	$90

Table 7.1-12
Estimated Off-highway Motorcycle Average Cost Per Ton of HC + NOx Reduced*
(7 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
near-term	$155	($48)	0.38	$410	$280
long-term	$95			$250	$120

* non-competition models only

Table 7.1-13
Estimated Snowmobile Average Cost Per Ton of CO Reduced
(3 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)		Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)		Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)	
			HC	CO	HC	CO	HC	CO
Phase 1 near-term	$73	($57)	0.50	1.25	$70	$30	$20	$10
Phase 1 long-term	$40				$40	$20	($20)	($10)
Phase 2 near-term	$131	($286)	0.12	n/a	$1,110	n/a	($1,305)	n/a
Phase 2 long-term	$77				$650	n/a	($1,770)	n/a
Phase 3 near-term	$89	($191)	n/a	0.31	n/a	$290	n/a	($330)
Phase 3 long-term	$54				n/a	$180	n/a	($450)

Table 7.1-14
Estimated ATV Average Cost Per Ton of HC + NOx Reduced
(3 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
Phase 1 near-term	$84	($24)	0.26	$330	$240
Phase 1 long-term	$42			$160	$70

Table 7.1-15
Estimated Off-highway Motorcycle Average Cost Per Ton of HC + NOx Reduced*
(3 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
near-term	$155	($48)	0.46	$340	$230
long-term	$95			$210	$100

* Non-competition models only

7.1.5 Recreational Vehicle Permeation Emissions

This section provides our estimate of the cost per ton of permeation emissions reduced for recreational vehicles. The analysis relies on the per vehicle costs estimated in Chapter 5 and the estimated lifetime emissions reductions (tons) presented in Chapter 6. All costs and emission reductions are discounted to the year of sale of the boats at a rate of 7 percent. Table 7.1-16 presents the cost per ton with and without consideration of the significant fuel savings that will result from evaporative emission control assuming a 7 percent discount rate. The cost per ton results assuming a 3 percent discount rate are presented in Table 7.1-17. As shown in these tables, the fuel savings more than offset the cost of the evaporative emission control technology.

Table 7.1-16
Estimated Cost Per Ton of HC Reduced (7 percent discount rate)

	Total Cost Per Vehicle	Lifetime Fuel Savings Per Vehicle (NPV)	Lifetime Reductions Per Vehicle (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
Snowmobiles					
tank permeation	$2	$5	0.0125	$185	($178)
hose permeation	$4	$7	0.0182	$234	($129)
total	$7	$11	0.0307	$214	($149)
All Terrain Vehicles					
tank permeation	$2	$3	0.0070	$215	($148)
hose permeation	$1	$3	0.0082	$157	($206)
total	$3	$6	0.0152	$184	($179)
Off-Highway Motorcycles					
tank permeation	$1	$1	0.0041	$348	($15)
hose permeation	$2	$3	0.0096	$175	($188)
total	$3	$5	0.0137	$226	($137)

Table 7.1-17
Estimated Cost Per Ton of HC Reduced (3 percent discount rate)

	Total Cost Per Vehicle	Lifetime Fuel Savings Per Vehicle (NPV)	Lifetime Reductions Per Vehicle (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
Snowmobiles					
tank permeation	$2	$5	0.0144	$161	($202)
hose permeation	$4	$8	0.0209	$204	($159)
total	$7	$13	0.0353	$186	($177)
All Terrain Vehicles					
tank permeation	$2	$3	0.0086	$175	($188)
hose permeation	$1	$4	0.0100	$128	($235)
total	$3	$7	0.0186	$150	($213)
Off-Highway Motorcycles					
tank permeation	$1	$2	0.0047	$302	($61)
hose permeation	$2	$4	0.0110	$152	($211)
total	$3	$6	0.0157	$197	($166)

7.2 Cost Per Ton for Other Mobile Source Control Programs

Because the primary purpose of cost-effectiveness is to compare our program to alternative programs, we made a comparison between the cost per ton values presented in this chapter and the cost-effectiveness of other programs. Table 7.2-1 summarizes the cost effectiveness of several recent EPA actions for controlled emissions from mobile sources. These values show that the cost-effectiveness of the standards for this rulemaking fall within the range of these other programs.

Table 7.2-1
Cost-effectiveness of Previously Implemented Mobile Source Programs (Costs Adjusted to 1997 Dollars)

Program	*$/ton*
Tier 2 vehicle/gasoline sulfur	1,340 - 2,260
2007 Highway HD diesel	1,458-1,867
2004 Highway HD diesel	212 - 414
Off-highway diesel engine	425 - 675
Tier 1 vehicle	2,054 - 2,792
NLEV	1,930
Marine SI engines	1,171 - 1,846
On-board diagnostics	2,313
Marine CI engines	24 - 176

The primary advantage of making comparisons to previously implemented programs is that their cost-effectiveness values were based on a rigorous analysis and are generally accepted as representative of the efficiency with which those programs reduce emissions. Unfortunately, previously implemented programs can be poor comparisons because they may not be representative of the cost-effectiveness of potential future programs. In the context of the Agency's rulemaking to revise the ozone and PM NAAQS[ii], the Agency compiled a list of additional known technologies that may be considered in devising new emission reductions strategies.[1] Through this broad review, over 50 technologies were identified to reduce NOx, VOC, or PM. The cost-effectiveness of these technologies averaged approximately $5,000/ton for VOC, $13,000/ton for NOx, and $40,000/ton for PM.

In summary, given the array of controls that will have to be implemented to make progress toward attaining and maintaining the NAAQS, we believe that the weight of the evidence from alternative means of providing substantial NOx + NMHC emission reductions indicates that our program is cost-effective. This is true from the perspective of other mobile source control programs or from the perspective of other stationary source technologies that might be considered.

7.3 20-Year Cost and Benefit Analysis

The following section presents the year-by-year cost and emission benefits associated with the standards for the 20-year period after implementation of the standards. For the categories where we expect a reduction in fuel consumption due to the standards, the fuel savings

[ii] This rulemaking was remanded by the D.C. Circuit Court on May 14, 1999. However, the analyses completed in support of that rulemaking are still relevant, since they were designed to investigate the cost-effectiveness of a wide variety of potential future emission control strategies.

are presented separately. The overall cost, incorporating the impact of the fuel savings is also presented.

Table 7.3-1 presents the year-by-year cost and emission benefits for the compression-ignition (CI) recreational marine requirements. (The numbers presented in Table 7.3-1 are not discounted.)

Table 7.3-1
Cost and Emission Benefits of the CI Recreational Marine Requirements

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	639	0	$7,806,010	$0	$7,806,010
2007	1,310	0	$8,365,319	$0	$8,365,319
2008	2,015	0	$8,573,839	$0	$8,573,839
2009	2,842	0	$9,413,530	$0	$9,413,530
2010	3,705	0	$9,637,035	$0	$9,637,035
2011	4,583	0	$5,213,411	$0	$5,213,411
2012	5,496	0	$5,176,672	$0	$5,176,672
2013	6,424	0	$5,290,764	$0	$5,290,764
2014	7,361	0	$4,958,052	$0	$4,958,052
2015	8,333	0	$5,062,713	$0	$5,062,713
2016	9,313	0	$5,167,682	$0	$5,167,682
2017	10,300	0	$5,272,652	$0	$5,272,652
2018	11,320	0	$5,377,623	$0	$5,377,623
2019	12,345	0	$5,482,592	$0	$5,482,592
2020	13,373	0	$5,587,562	$0	$5,587,562
2021	14,407	0	$5,692,532	$0	$5,692,532
2022	15,416	0	$5,797,503	$0	$5,797,503
2023	16,423	0	$5,902,472	$0	$5,902,472
2024	17,379	0	$6,007,442	$0	$6,007,442
2025	18,190	0	$6,112,413	$0	$6,112,413

Table 7.3-2 presents the sum of the costs and emission benefits over the twenty year period after the CI recreational marine requirements take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-year period (assuming the seven percent discount rate) are also presented.

Table 7.3-2
Annualized Cost and Emission Benefits for the Period 2006-2025
due to the CI Recreational Marine Requirements

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 20-year Value	181,174	0	$125.9	$0.0	$125.9
Discounted 20-year Value	79,294	0	$75.6	$0.0	$75.6
Annualized Value	7,485	0	$7.1	$0.0	$7.1

Table 7.3-3 presents the year-by-year cost and emission benefits for the large spark-ignition (SI) engine exhaust and evaporative requirements. (The numbers presented in Table 7.3-3 are <u>not</u> discounted.)

Table 7.3-3
Cost and Emission Benefits of the Large SI Engine Requirements

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2004	77,259	82,130	$88,806,711	$52,725,475	$36,081,236
2005	133,247	161,404	$91,185,462	$102,980,886	($11,795,424)
2006	187,149	239,617	$75,632,060	$152,926,193	($77,294,133)
2007	265,975	474,426	$84,493,379	$198,943,367	($114,449,988)
2008	329,756	678,940	$86,588,256	$242,829,040	($156,240,784)
2009	391,853	883,333	$68,943,347	$285,094,033	($216,150,686)
2010	451,604	1,076,572	$70,571,930	$325,741,703	($255,169,773)
2011	506,031	1,260,180	$72,200,513	$360,969,773	($288,769,260)
2012	542,932	1,427,950	$68,895,067	$379,398,454	($310,503,387)
2013	576,173	1,589,734	$70,414,812	$395,033,152	($324,618,340)
2014	606,048	1,730,897	$71,934,556	$408,985,187	($337,050,631)
2015	627,504	1,803,389	$73,454,300	$421,230,723	($347,776,423)
2016	646,713	1,866,433	$74,974,044	$432,435,409	($357,461,365)
2017	664,729	1,922,727	$76,493,788	$443,121,586	($366,627,798)
2018	681,633	1,972,496	$78,013,532	$453,291,958	($375,278,426)
2019	697,598	2,017,393	$79,533,276	$462,975,097	($383,441,821)
2020	712,638	2,059,586	$81,053,020	$471,991,726	($390,938,706)
2021	727,377	2,099,624	$82,572,765	$480,919,953	($398,347,188)
2022	741,822	2,137,602	$84,092,509	$489,742,176	($405,649,667)
2023	756,116	2,176,504	$85,612,253	$498,805,313	($413,193,060)

Table 7.3-4 presents the sum of the costs and emission benefits over the twenty year period after the large SI engine exhaust and evaporative requirements are to take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-year period (assuming the seven percent discount rate) are also presented.

Table 7.3-4
Annualized Cost and Emission Benefits for the Period 2004-2023
due to the Large SI Engine Requirements

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 20-year Value	10,324,157	27,660,937	$1,565.5	$7,060.1	($5,494.7)
Discounted 20-year Value	4,945,366	12,631,259	$892.4	$3,433.5	($2,541.1)
Annualized Value	466,808	1,192,303	$84.2	$324.1	($239.9)

Table 7.3-5 presents the year-by-year cost and emission benefits for the snowmobile exhaust and permeation requirements. (The numbers presented in Table 7.3-5 are not discounted.)

Table 7.3-5
Cost and Emission Benefits of the Snowmobile Requirements

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	3,933	9,941	$6,583,529	$391,491	$6,192,038
2007	12,374	31,272	$13,546,439	$1,225,462	$12,320,977
2008	22,502	54,058	$13,183,508	$2,469,788	$10,713,720
2009	32,977	77,582	$13,455,182	$3,747,560	$9,707,622
2010	45,890	105,287	$38,933,137	$9,545,473	$29,387,664
2011	59,319	134,052	$38,685,132	$15,633,653	$23,051,479
2012	76,209	169,882	$51,957,587	$25,065,896	$26,891,691
2013	93,845	207,354	$52,701,157	$34,856,171	$17,844,987
2014	112,031	245,980	$45,309,024	$44,859,909	$449,115
2015	130,397	284,962	$44,402,290	$54,975,510	($10,573,219)
2016	148,455	323,196	$41,860,214	$65,045,977	($23,185,764)
2017	165,914	360,691	$41,738,365	$74,963,244	($33,224,879)
2018	181,480	394,252	$42,211,850	$84,545,886	($42,334,036)
2019	194,065	420,522	$42,677,612	$93,597,148	($50,919,536)
2020	204,737	442,187	$43,138,523	$102,179,264	($59,040,741)
2021	214,492	461,929	$43,138,523	$110,195,147	($67,056,624)
2022	222,824	478,985	$43,138,523	$116,664,922	($73,526,400)
2023	229,775	493,443	$43,138,523	$121,533,783	($78,395,261)
2024	235,195	504,816	$43,138,523	$125,181,189	($82,042,667)
2025	239,208	513,372	$43,138,523	$127,680,885	($84,542,362)

Table 7.3-6 presents the sum of the costs and emission benefits over the twenty year period after the exhaust and permeation requirements for snowmobiles take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-year period (assuming the seven percent discount rate) are also presented.

Table 7.3-6
Annualized Cost and Emission Benefits for the Period 2006-2025
due to the Snowmobile Requirements

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 20-year Value	2,625,622	5,713,763	$746.1	$1,214.4	($552.9)
Discounted 20-year Value	1,141,218	2,499,999	$379.9	$494.6	($145.8)
Annualized Value	107,723	235,983	$35.9	$46.7	($10.8)

Table 7.3-7 presents the year-by-year cost and emission benefits for the exhaust and permeation requirements for ATVs. (The numbers presented in Table 7.3-7 are not discounted.)

Table 7.3-7
Cost and Emission Benefits of the ATV Requirements

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	6,321	4,380	$42,463,856	$933,911	$41,529,945
2007	23,496	14,702	$79,998,942	$4,771,537	$75,227,405
2008	44,313	26,267	$76,517,949	$9,546,220	$66,971,729
2009	69,788	39,269	$70,286,998	$13,556,430	$56,730,568
2010	97,132	53,061	$65,302,237	$17,819,539	$47,482,698
2011	125,655	67,377	$56,379,476	$22,221,930	$34,157,546
2012	154,669	81,890	$52,441,476	$26,654,575	$25,786,901
2013	183,543	96,230	$52,441,476	$31,026,962	$21,414,514
2014	211,466	110,237	$52,441,476	$35,203,428	$17,238,048
2015	238,164	123,603	$52,441,476	$39,163,369	$13,278,107
2016	263,043	136,030	$49,999,146	$42,825,354	$7,173,792
2017	285,924	147,442	$47,556,815	$46,173,993	$1,382,822
2018	304,746	156,446	$47,556,815	$48,949,487	($1,392,672)
2019	316,793	161,571	$47,556,815	$50,819,932	($3,263,117)
2020	324,521	164,444	$47,556,815	$52,105,004	($4,548,189)
2021	329,849	166,533	$47,556,815	$52,985,302	($5,428,487)
2022	333,031	167,857	$47,556,815	$53,516,650	($5,959,835)
2023	335,389	168,858	$47,556,815	$53,912,720	($6,355,905)
2024	337,137	169,554	$47,556,815	$54,215,317	($6,658,502)
2025	338,413	170,055	$47,556,815	$54,442,855	($6,886,040)

Table 7.3-8 presents the sum of the costs and emission benefits over the twenty year period after the exhaust and permeation requirements for ATVs take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-year period (assuming the seven percent discount rate) are also presented.

Table 7.3-8
Annualized Cost and Emission Benefits for the Period 2006-2025
due to the ATV Requirements

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 20-year Value	4,323,393	2,225,806	$1,078.7	$710.8	$367.9
Discounted 20-year Value	1,951,668	1,014,866	$641.0	$325.3	$315.7
Annualized Value	184,224	95,796	$60.5	$30.7	$29.8

Table 7.3-9 presents the year-by-year cost and emission benefits for the off-highway motorcycle exhaust and permeation requirements. (The numbers presented in Table 7.3-9 are not discounted.

Table 7.3-9
Cost and Emission Benefits of the Off-Highway Motorcycle Requirements

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	3,085	2,330	$16,269,072	$633,450	$15,635,622
2007	9,742	7,398	$31,813,960	$2,061,773	$29,752,187
2008	18,028	13,408	$29,592,786	$3,878,230	$25,714,556
2009	27,409	20,236	$26,871,067	$5,903,201	$20,967,866
2010	37,325	27,463	$24,698,975	$8,016,233	$16,682,742
2011	47,542	34,917	$21,818,012	$10,166,886	$11,651,126
2012	57,733	42,364	$21,366,690	$12,282,632	$9,084,058
2013	67,631	49,612	$21,580,357	$14,311,527	$7,268,830
2014	77,400	56,774	$21,796,160	$16,290,860	$5,505,300
2015	86,976	63,810	$22,014,121	$18,207,111	$3,807,010
2016	96,030	70,471	$22,234,263	$19,981,626	$2,252,637
2017	103,553	76,047	$22,456,605	$21,421,145	$1,035,460
2018	108,707	79,882	$22,681,171	$22,409,671	$271,500
2019	112,249	82,490	$22,907,983	$23,107,057	($199,074)
2020	114,994	84,503	$23,137,063	$23,655,679	($518,616)
2021	117,320	86,207	$23,368,434	$24,122,020	($753,586)
2022	119,371	87,712	$23,602,118	$24,532,680	($930,562)
2023	121,137	89,007	$23,838,139	$24,886,440	($1,048,301)
2024	122,719	90,173	$24,076,521	$25,200,670	($1,124,149)
2025	124,218	91,284	$24,317,286	$25,496,728	($1,179,442)

Table 7.3-10 presents the sum of the costs and emission benefits over the twenty year period after the exhaust and permeation requirements for off-highway motorcycles take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-year period (assuming the seven percent discount rate) are also presented.

Table 7.3-10
Annualized Cost and Emission Benefits for the Period 2006-2025 due to the Off-Highway Motorcycle Requirements

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 20-year Value	1,573,169	1,156,088	$470.4	$326.6	$143.9
Discounted 20-year Value	715,044	525,674	$268.9	$149.1	$119.8
Annualized Value	67,495	49,620	$25.4	$14.1	$11.3

Table 7.3-11 presents the year-by-year cost and emission benefits for all of the requirements. (The numbers presented in Table 7.3-11 are <u>not</u> discounted.)

Table 7.3-11
Cost and Emission Benefits of the Requirements for All Equipment Categories

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2004	77,259	82,130	$88,806,711	$52,725,475	$36,081,236
2005	133,247	161,404	$91,185,462	$102,980,886	($11,795,424)
2006	201,127	256,268	$148,754,528	$154,885,046	($6,130,518)
2007	312,897	527,798	$218,218,038	$207,002,139	$11,215,899
2008	416,614	772,673	$214,456,337	$258,723,278	($44,266,941)
2009	524,869	1,020,420	$188,970,125	$308,301,224	($119,331,100)
2010	635,656	1,262,383	$209,143,314	$361,122,948	($151,979,633)
2011	743,130	1,496,526	$194,296,545	$408,992,242	($214,695,697)
2012	837,039	1,722,086	$199,837,493	$443,401,557	($243,564,064)
2013	927,616	1,942,930	$202,428,566	$475,227,812	($272,799,246)
2014	1,014,306	2,143,888	$196,439,267	$505,339,384	($308,900,116)
2015	1,091,374	2,275,764	$197,374,901	$533,576,713	($336,201,812)
2016	1,163,554	2,396,130	$194,235,348	$560,288,366	($366,053,018)
2017	1,230,420	2,506,907	$193,518,225	$585,679,968	($392,161,743)
2018	1,287,886	2,603,076	$195,840,991	$609,197,002	($413,356,011)
2019	1,333,050	2,681,976	$198,158,277	$630,499,234	($432,340,957)
2020	1,370,263	2,750,720	$200,472,982	$649,931,673	($449,458,691)
2021	1,403,445	2,814,293	$202,329,067	$668,222,422	($465,893,354)
2022	1,432,464	2,872,156	$204,187,466	$684,456,428	($480,268,962)
2023	1,458,840	2,927,812	$206,048,201	$699,138,256	($493,090,055)
2024	1,482,773	2,980,012	$207,911,297	$712,465,187	($504,553,890)
2025	1,504,484	3,028,620	$209,776,777	$724,482,067	($514,705,289)

Table 7.3-12 presents the sum of the costs and emission benefits over the twenty-two year period after all of the requirements take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-two year period (assuming the seven percent discount rate) are also presented. (A twenty-two period is used in this aggregate analysis to cover the first twenty years of each of the standards which begins in 2004 for large SI engines and concludes in 2006 for the other categories of equipment.)

Table 7.3-12
Annualized Cost and Emission Benefits for the Period 2004-2025
due to the Requirements for All Equipment

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 22-year Value	22,106,425	44,300,504	$4,374.0	$11,072.1	($6,698.1)
Discounted 22-year Value	9,073,158	17,971,253	$2,176.7	$4,701.9	($2,525.2)
Annualized Value	789,161	1,561,958	$192.5	$410.1	($217.6)

Chapter 7 References

1.“Regulatory Impact Analyses for the Particulate Matter and Ozone National Ambient Air Quality Standards and Regional Haze Rule,” Appendix B, “Summary of control measures in the PM, regional haze, and ozone partial attainment analyses,” Innovative Strategies and Economics Group, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC, July 17, 1997, Docket A-2000-01, Document II-A-77.

Chapter 8: Small Business Flexibility Analysis

This section presents our Small Business Flexibility Analysis (SBFA) which evaluates the impacts of the rule on small businesses. Prior to issuing our proposal, we analyzed the potential impacts of our program on small businesses. As a part of this analysis, we convened two Small Business Advocacy Review (SBAR) Panels, under the requirements of the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), 5 USC 601 *et seq*. Through the two Panel processes, we gathered advice and recommendations from small entity representatives (SERs) who would be affected by the regulation. The two Panel reports have been placed in the rulemaking record.

8.1 Requirements of the Regulatory Flexibility Act

The Regulatory Flexibility Act was amended by SBREFA to ensure that concerns regarding small entities are adequately considered during the development of new regulations that affect them. Although we are not required by the Clean Air Act to provide special treatment to small businesses, the Regulatory Flexibility Act requires us to carefully consider the economic impacts that our proposed rules will have on small entities. In general, the Regulatory Flexibility Act calls for determining, to the extent feasible, a rule’s economic impact on small entities, exploring regulatory options for reducing any significant economic impact on a substantial number of such entities, and explaining the ultimate choice of regulatory approach.

For purposes of assessing the impacts of this final rule on small entities, a small entity is defined as: (1) a small business that meet the definition for business based on SBA size standards; (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field. This rulemaking will only affect the small businesses.

When proposing rules subject to notice and comment under the Clean Air Act, we are generally required under the Regulatory Flexibility Act to conduct an Initial Regulatory Flexibility Analysis, unless we certify that the requirements of a regulation will not cause a significant impact on a substantial number of small entities. Although we are not required to conduct a Final Regulatory Flexibility Analysis (FRFA), EPA has decided to prepare an assessment of the impacts of the final rule on small entities. This SBFA would meet the requirements of a FRFA, were EPA required to prepare one.

In accordance with section 609 of the RFA, EPA conducted an outreach to affected small entities and convened a Small Business Advocacy Review (SBAR) Panel prior to proposing this rule, to obtain advice and recommendations of representatives of the small entities that potentially would be subject to the rule's requirements. Through the Panel process, we gathered advice and recommendations from small-entity representatives who would be affected by the regulation, and published the results in a Final Panel Report, dated July 17, 2001. EPA had previously convened a separate Panel for marine engines and vessels. This panel also produced a report, dated August 25, 1999. We also prepared an Initial Regulatory Flexibility Analysis (IRFA) in accordance with section 603 of the Regulatory Flexibility Act. The IRFA is found in chapter 8 of the Draft Regulatory Support Document. Both Panel reports and the IRFA have been placed in the docket for this rulemaking (Public Docket A-2000-01, items II-A-85, II-F-22, and III-B-01).

We proposed the majority of the Panel recommendations, and took comments on this and other issues. The information we received during the course of the rulemaking indicated that fewer small entities than we had first estimated would be significantly impacted by the rule. During the SBAR Panel process, we were concerned that ATV and off-highway motorcycle importers would have limited access to certified models for import. We received no comments confirming this concern and believe that the use of cleaner four-stroke engines in these vehicles will continue to increase. As a result, we believe all these small companies should be able to find manufacturers that are able to supply compliant engines for import into the U.S. These importers incur no development costs, and they are not involved in adding emission-control hardware or other variable costs to provide a finished product to market. We also expect that importers would select vehicles for import that have fuel tanks and hoses that comply with the permeation standards. However, even if they were not able to find such vehicles, the few additional dollars per vehicle that it would cost to bring them into compliance with the permeation standards is insignificant in comparison with the normal selling prices for these vehicles. They should therefore expect to buy and sell their products with the normal markup to cover their costs and profit. As noted below, we expect all 21 known small-business importers to face compliance costs of less than one percent of their revenues. Thus, EPA has determined that this final rule will not have a significant economic impact on a substantial number of small entities. Also, as a result of comments received on the proposal, we are finalizing changes that we believe will further reduce the level of impact to small entities directly regulated by the rule. These changes and can be found below in Section 8.6, "Steps Taken to Minimize the Economic Impact on Small Entities."

The key elements of the Small Business Flexibility Analysis include:

- the need for and objectives of the rule;

- the significant issues raised by public comments, a summary of the Agency's assessment of those issues, and a statement of any changes made to the rule as a result of those comments;

- the types and number of affected small entities to which this rule will apply;

- the projected reporting, record keeping, and other compliance requirements of the regulation, including the classes of small entities that would be affected and the type of professional skills necessary for preparation of the report or record;

- the steps taken to minimize the economic impacts of the regulation on small entities, consistent with the stated objectives of the applicable statutes.

8.2 Need For and Objectives of the Rule

The process of establishing standards for nonroad engines began in 1991 with a study to determine whether emissions of carbon monoxide (CO), oxides of nitrogen (NOx), and volatile organic compounds (VOCs) from new and existing nonroad engines, equipment, and vehicles are significant contributors to ozone and CO concentrations in more than one area that has failed to attain the national ambient air quality standards for ozone and CO.[jj] In 1994, EPA finalized its finding that nonroad engines as a whole "are significant contributors to ozone or carbon monoxide concentrations" in more than one ozone or carbon monoxide nonattainment area.[kk]

Upon making this finding, the Clean Air Act (CAA or the Act) requires EPA to establish standards for all classes or categories of new nonroad engines that cause or contribute to air quality nonattainment in more than one ozone or carbon monoxide (CO) nonattainment area. Since the finding in 1994, EPA has been engaged in the process of establishing programs to control emissions from nonroad engines used in many different applications. Nonroad categories already regulated include:

- Land-based compression ignition (CI) engines (e.g., farm and construction equipment),
- Small land-based spark-ignition (SI) engines (e.g., lawn and garden equipment, string trimmers),
- Marine engines (outboards, personal watercraft, CI commercial, CI engines <37kW)
- Locomotive engines

On December 7, 2000, EPA issued an Advance Notice of Proposed Rulemaking (ANPRM), and then issued a Notice of Proposed Rulemaking (NPRM) on September 14, 2001. This final rule continues the process of establishing standards for nonroad engines and vehicles, as required by CAA section 213(a)(3), with new emission standards for recreational marine diesel engines, recreational vehicles, and other nonroad spark-ignition engines over 19 kW.

8.3 Issues Raised by Public Comments

The two SBAR Panels considered a wide range of options and regulatory alternatives for providing small businesses with flexibility in complying with the regulation. As part of the process, the Panels requested and received comment on several ideas for flexibility that were suggested by SERs and Panel members. The major options recommended by the Panel can be

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[jj] "Nonroad Engine and Vehicle Emission Study—Report and Appendices," EPA-21A-201, November 1991 (available in Air docket A-91-24). It is also available through the National Technical Information Service, referenced as document PB 92-126960.

[kk] 59 FR 31306 (July 17, 1994).

found in Section 9 of the Panel Reports.

Many of the flexible approaches recommended by the Panels can be applied to several of the equipment categories that may be affected by the regulation. However, during the consultation process, it became evident that, in a few situations, it could be helpful to small entities if unique provisions were available. Three such provisions are described below.

(a) Snowmobiles: The Panel recommended that EPA seek comment on a provision allowing small snowmobile manufacturers to request a relaxed standard for one or more engine families, up to 300 engines per year, until the family is retired or modified, if such a standard is justifiable based on the criteria described in the Panel report. Based on comments received, we have adopted this provision, increasing the sales allowance to 600 engines per year.

(b) ATVs and Off-road Motorcycles: The Panel recommended that the hardship provision for ATVs and off-road motorcycles allow for annual review of the relief for up to two years for importers to obtain complying products. We are adopting this provision.

(c) Large SI: The Panel recommended that small entities be granted the flexibility initially to reclassify a small number of their small displacement engines into EPA's small spark-ignition engine program (40 CFR part 90). Small entities would be allowed to use those requirements instead of the requirements we adopt for large entities. We are not adopting this provision, preferring instead to rely on the more flexible approach provided under the hardship provisions. Since there are only two companies affected, we believe this approach best addresses these concerns.

The Panel also crafted recommendations to address SERs' concerns that ATV and off-road motorcycle standards that essentially required manufacturers to switch to four-stroke engines might increase costs to the point that many small importers and manufacturers could experience significant adverse effects. The Panel recommended that EPA request comment in its proposed rule on the effect of the regulation on these small entities, with the specific intent of developing information—including the extent to which sales of their products would likely to be reduced in response to changes in product price attributable to the standards—that could be used to inform a decision in the final rule as to whether EPA should provide additional flexibility beyond that considered by the Panel. We received no comments addressing this concern and therefore believe that the use of four-stroke engines for ATVs and off-highway motorcycles will continue to increase; as a result all these companies should be able to find manufacturers that are able to supply compliant engines into the U.S. market.

In the NPRM for this rule, we proposed only exhaust emission controls for recreational vehicles. However, several commenters raised the issue of control of evaporative emissions related to permeation from fuel tanks and fuel hoses, and indicated that our obligations under section 213 of the Clean Air Act included control of permeation emissions. The commenters pointed to work done by the California Air Resources Board (ARB) on permeation emissions from plastic fuel tanks and rubber fuel line hoses for various types of nonroad equipment, as well as portable plastic fuel containers, as evidence of a new emissions concern. Our own investigation into the hydrocarbon emissions related to permeation of fuel tanks and fuel hoses from recreational land-based and marine applications supports the concerns raised by the commenters. Therefore, on May 1, 2002, we published a notice in the Federal Register reopening the comment period and requesting comment on possible approaches to regulating permeation emissions from recreational vehicles. The notice provided a detailed analysis of possible approaches to regulating permeation emissions and the expected costs and emission reductions from these approaches. The notice also cited sample regulation language that could be used if we decided to finalize such requirements. Commenters had thirty days from May 1, 2002 to provide comments on the notice. We received comments from several affected manufacturers during the comment period, including at least one small entity. These comments have been addressed in the final Summary and Analysis of Comments document, and we have made several changes to the rule in response to suggestions of the commenters.

We received a number of other comments from engine and equipment manufacturers and consumers during the comment period after we issued the NPRM. A number of small engine and equipment manufacturers commented on the financial hardships they would face in complying with the proposed regulations. Most requested that we consider a number of hardship provisions, primarily an exemption from or a delay in the implementation of the proposed standards, or certain flexibilities in the certification process. Due to the wide variety of engines, vehicles, and equipment covered by this rulemaking, we decided that a variety of provisions were needed to address the concerns of the small entities involved. A summary of the comments pertaining to these small entity issues can be found in our Final Summary and Analysis of Comments document contained in the public docket for this rulemaking. Changes to the proposal as a result of SER or other comments are noted below in section 8.6 for each of the sectors affected by this rule.

8.4 Description of Affected Entities

Table 8.4-1 provides an overview of the primary SBA small business categories potentially affected by this regulation.

Table 8.4-1
Primary SBA Small Business Categories Potentially Affected by this Regulation

Industry	NAICS[a] Codes	Defined by SBA as a Small Business If:[b]
Motorcycles and motorcycle parts manufacturers	336991	<500 employees
Snowmobile and ATV manufacturers	336999	<500 employees
Independent Commercial Importers of Vehicles and parts	421110	<100 employees
Nonroad SI engines	333618	<1,000 employees
Internal Combustion Engines	333618	<1000 employees
Boat Building and Repairing	336612	<500 employees

a. North American Industry Classification System
b. According to SBA's regulations (13 CFR part 121), businesses with no more than the listed number of employees or dollars in annual receipts are considered "small entities" for purposes of a regulatory flexibility analysis.

8.4.1 Recreational Vehicles (ATVs, off-highway motorcycles, and snowmobiles)

The ATV sector has the broadest assortment of manufacturers. There are seven companies, Bombardier, Honda, Polaris, Kawasaki, Yamaha, Suzuki, and Arctic Cat, representing over 95 percent of total domestic ATV sales. The remaining 5 percent come from one small manufacturer, IPC, and a number of importers who tend to import inexpensive, youth-oriented ATVs from China and other Asian nations.. EPA has identified 21 small companies (as defined in Table 8.4.1, above) that offer off-road motorcycles, ATVs, or both products. Annual unit sales for these companies can range from a few hundred to several thousand units per year.

We expect all 21 known small-business importers to face compliance costs less than one percent of their revenues. These companies incur no development costs and they are not involved in adding emission-control hardware or other variable costs to provide a finished product to market. As a result, they should expect to buy and sell their products with the normal mark-up to cover their costs and profit. During the SBAR Panel process, we were also concerned that importers would have limited access to certified models for import. We received no comments confirming this concern and believe that the supply of four-stroke engines for ATVs and off-highway motorcycles will continue to increase; as a result all these companies should be able to find manufacturers that are able to supply compliant engines into the U.S. market. We also received no comments regarding the permeation standards issue, and believe that the importers will simply purchase compliant models and pass the costs on to the ultimate consumers.

Five large manufacturers, Honda, Kawasaki, Yamaha, Suzuki, and KTM. accounted for approximately 85 percent of all off-highway motorcycle production for sale in the U.S. There are three small business manufacturing off-highway motorcycles in the U.S. Two of these companies make only competition models, so they don't need to certify their products under this regulation. ATK already offers engines that should be meeting the new emission standards, especially under our provisions allowing design-based certification, so we estimate that their compliance costs will be much less than one percent of their revenues.

IPC is the only small business manufacturing ATVs, offering two separate youth ATV models. IPC already uses four-stroke engines. Moreover, the standards are based on emissions per kilometer, which are easier to meet for models with small-displacement engines. We estimate compliance costs of about $50,000 for R&D plus $15,000 for certification, which is much less than 1 percent of IPC's annual revenues.

We do not believe that compliance with the permeation standards will place a significant burden on either the small manufacturers or on the importers. We have estimated the cost of compliance for ATVs and off-highway motorcycles at roughly three dollars per vehicle for the fuel hoses and surface coating for the fuel tank. This estimate includes shipping, and is based on buying the necessary hoses and surface treatment for the fuel tanks from outside suppliers. Thus, no capital outlays are required, and the increase in vehicle cost is insignificant, so that it can easily be passed along to the ultimate consumer. However, to ensure that these requirements do not adversely affect small manufacturers, we are implementing, where they are applicable to permeation, the same flexibility options we proposed for the exhaust emission standards.

Based on available industry information, four major manufacturers, Arctic Cat, Bombardier (also known as Ski-Doo), Polaris, and Yamaha, account for over 99 percent of all domestic snowmobile sales. The remaining one percent comes from very small manufacturers who tend to specialize in unique and high performance designs. There is also one potential manufacturer (Redline), which we have learned is owned by a larger entity (TMAG) and is therefore not a small business, that hopes to produce snowmobiles within the next year.

We are aware of five small businesses that have been producing snowmobiles. Two of these have discontinued production since we completed the SBAR panel. Two of the remaining three manufacturers (Crazy Mountain and Fast, Inc.) specialize in high performance versions of standard recreational snowmobile types (i.e., travel and mountain sleds). The other manufacturer (Fast Trax) produces a unique design, which is a scooter-like snowmobile designed to be ridden standing up. Most of these manufacturers build less than 50 units per year.

Fast, Inc. produces four engine models, one of which is a four-stroke design. The four-stroke engine will need no development or certification work, since we allow design-based certification for this situation. We expect the two-stroke engines to qualify for the special standards that apply to small businesses. As a result, Fast will have only limited development costs to reduce emissions from these engines. We estimate a total of $75,000 in R&D and $15,000 for certification for each of the three engine families. They are projecting sales of around 1,000 units for the time when standards would apply. Since this is a substantial increase over their current volume of 180 per year, we base revenue calculations on projected sales of only 500 per year. The resulting calculation shows a compliance burden less than one percent.

Fast, Inc. was the only recreational vehicle manufacturer to comment on the permeation provisions contained in the May 1 notice. Fast stated that, as a small manufacturer of snowmobiles, they would undergo additional hardship due to this rule, because they do not have the sales volume to warrant installing the barrier treatment equipment for fuel tanks. They also commented that shipping and processing of fuel tanks by an outside vendor could take 3-4 months, and that as a small business it would be unworkable for them to tie up funds for such a long period.

We agree that it is neither necessary nor cost-effective for a small manufacturer to make the capital investment necessary for an in-house treatment facility, given the relatively low cost of the compliance with the requirements and the availability of materials and treatment support by outside vendors. Low permeation fuel hoses are available from vendors today, and we would expect that surface treatment would be applied through an outside company. The $5 to $7 per vehicle incremental cost resulting from the permeation requirements is insignificant compared to the price of one of these high-end sleds, and should not pose a significant cash-flow problem, particularly in view of the likely sales volumes involved. These costs are based on vendor costs, including shipping charges.

Since the costs are low and no capital investment is required, we believe that the permeation control requirements should be relatively easy for small businesses to meet. However, to make sure that these requirements do not adversely affect small entities, we are implementing, where they are applicable to permeation, the same flexibility options we proposed for the recreational vehicle exhaust emission standards . These flexibility options included a 2 year delay of the standards, design-based certification, broader engine families, waiving production line testing, use of assigned deterioration factors, carryover of certification data, ABT, and hardship provisions. These are further described below in section 8.6.. Given the low costs and these flexibilities, there should be no significant economic impact on small entities.

Crazy Mountain produces only about 20 snowmobiles per year in addition to their more extensive business in aftermarket parts and accessories for snowmobiles from other manufacturers. We don't have revenue information for the whole company, but we expect that total costs of redesigning and certifying their single model will exceed 3 percent of snowmobile revenues. However, with its low production volume, Crazy Mountain could likely qualify for the special standards that apply to small businesses.

Fast Trax provided no response to repeated outreach efforts to determine potential economic effects of the final rule. We expect them to purchase compliant engines, which would result in a compliance burden of less than one percent. Due to the small engine displacements used in current models, we would expect these engines to be certified to the Small SI standards.

8.4.2 Large Spark Ignition Engines

The Panel was aware of one engine manufacturer of Large SI engines that qualifies as a small business. Westerbeke plans to produce engines that meet the standards adopted by CARB in 2004, with the possible exception of one engine family. If EPA adopts long-term standards, this would require manufacturers to do additional calibration and testing work. If EPA adopts new test procedures (including transient operation), there may also be a cost associated with upgrading test facilities. We expect that Westerbeke will face relatively small compliance costs as a result of this rule, since the California-compliant engines will need only a small amount of additional development effort to meet the long-term standards. We estimate that they will need $200,000 each for two engine families, with a potential need to spend an additional $300,000 for upgrading test cells. These costs are less than one percent of their annual revenues.

Since we completed the proposal Wisconsin Motors, a small business, bought the assets of a company that had gone bankrupt. This company did not exist during the SBAR Panel process associated with this rule. Through public comments and other outreach efforts, this company has stated that it faces significant development costs, though much of this effort is required to improve the engine enough to sustain a market presence as other manufacturers continue to make improvements to competitive engines. Under the hardship provisions, we expect them to spread compliance costs over several years to reduce the impact of emission standards. Wisconsin should be able to delay compliance until they are able to retool for production and add developmental efforts to incorporate emission-control technologies. Substantial tooling expenses will be necessary independent of emission standards. We estimate a need for $500,000 for emission-measurement facilities and $500,000 of development costs for each of two engine models. New testing to certify and show compliance on these models comes to about $50,000 total. These costs are about 4 percent of the projected revenues for the time frame when Wisconsin will be certifying their engines. Since this manufacturer is operating in a niche market with customers providing public comments citing the need for these engines, we expect that most of the increased cost of production will be recovered by increased revenues.

8.4.3 Marine Vessels

Marine vessels include the boat, engine, and fuel system. Exhaust emission controls including NTE requirements, as addressed in the two Panel Reports, would affect the engine manufacturers and may affect boat builders.

8.4.3.1 Small Diesel Engine Marinizers

We have determined that there are at least 16 companies that manufacture diesel engines for recreational vessels. Nearly 75 percent of diesel engines sales for recreational vessels in 2000 can be attributed to three large companies. Six of the 16 identified companies are considered small businesses as defined by SBA. Based on sales estimates for 2000, these six companies represent approximately 4 percent of recreational marine diesel engine sales. The remaining companies each comprise between two and seven percent of sales for 2000.

We are thus aware of six small businesses that may produce recreational marine diesel engines. Alaska Diesel and Westerbeke do not offer recreational versions of the marine diesel engines that are different than their commercial products. The regulations allow manufacturers to certify all their products under the commercial standards, even if they may be used in recreational applications. As a result, these companies would likely minimize their costs by certifying all their products to the commercial standards. We therefore believe that they will experience no significant new compliance costs for these engines as a result of this regulation. Daytona has, to the best of our knowledge, discontinued production of their marine product line.

For those companies that will be certifying recreational marine diesel engines, we directly apply the development and certification costs from Chapter 5. For each engine family, we estimate $200,000 of development costs and $30,000 of certification costs. The variable costs considered in Chapter 5 are very small relative to the price of the engines, so we would expect manufacturers to fully recover these costs over time.

American Diesel is a small business for which we were unable to identify gross revenues. However, based on the fact that they reported an employee count of 17, we can reasonably estimate their business volume. They produce a single engine model, so their total estimated fixed costs are $230,000. For compliance costs to fall in the range of 1 to 3 percent of annual revenues, total revenues would need to be between $2.5 and $7.6 million. This is a reasonable estimate compared to other companies producing these engines with a similar number of employees.

Marine Power also sells only a single model. Comparing fixed costs (spread over three years) to their estimated annual revenues of $10 million shows that their compliance burden is 0.8 percent of revenues.

Peninsular Diesel has annual revenues of about $2 million from three employees. They also sell a single engine model. Their estimated compliance burden is 3.8 percent of revenues.

8.4.3.2 Small Recreational Boat Builders

We have less precise information about recreational boat builders than is available about engine manufacturers. We have utilized several sources, including trade associations and

Internet sites when identifying entities that build or sell recreational boats. We have also worked with an independent contractor to assist in the characterization of this segment of the industry. Finally, we received a list of nearly 1,700 boat builders known to the U.S. Coast Guard to produce boats using engines for propulsion. More than 90% of the companies identified so far would be considered small businesses as defined by SBA (NAIC code 336612).

8.4.4 Results for All Small entities

For this regulation as a whole, we expect 32 small businesses to have total compliance costs less than 1 percent of their annual revenues. We estimate that one company will have compliance costs between 1 and 3 percent of revenues. Three companies will likely have compliance costs exceeding 3 percent of revenues, but at least one will likely be able to benefit from the relief provisions outlined below. These estimates include the costs for compliance with the permeation standards.

8.5 Projected Reporting, Recordkeeping, and Other Compliance Requirements of the Regulation

For any emission control program, we be sure that the regulated engines will meet the standards. Historically, EPA programs have included provisions placing manufacturers responsible for providing these assurances. This final rule includes testing, reporting, and record keeping requirements. Testing requirements for some manufacturers include certification (including deterioration testing), and production-line testing. Reporting requirements include test data and technical data on the engines including defect reporting. Manufacturers keep records of this information.

8.6 Steps to Minimize Significant Economic Impact on Small Entities

EPA conducted outreach to small entities and convened two Small Business Advocacy Review Panels to obtain advice and recommendations of representatives of the small entities that potentially would be subject to the rule's requirements. The first panel covered only marine engines and vessels. That Panel published its report on August 29, 1999, and where appropriate, its recommendations have been incorporated into this analysis. In a subsequent Federal Register notice dated May 2, 2002 (67 FR 21613), EPA sought comment on applying permeation control standards for fuel tanks and fuel hoses used on recreational vehicles. These provisions would generally apply to those controls as well.

On May 3, 2001, EPA’s Small Business Advocacy Chairperson convened a second Panel covering all engine/vehicle categories in this rulemaking, under Section 609(b) of the Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA). In addition to the Chair, the Panel consisted of the Director of the Assessment and Standards Division (ASD) within EPA's Office of Transportation and Air Quality, the Chief Counsel for Advocacy of the Small Business Administration, and the Deputy Administrator of the Office of Information and Regulatory Affairs within the Office of Management and Budget. As part of the SBAR process, the Panel met with small entity representatives (SERs) to discuss the potential emission standards and, in addition to the oral comments from SERs, the Panel solicited written input. In the months preceding the Panel process, EPA conducted outreach with small entities from each of the five sectors as described above. On May 18, 2001, the Panel distributed an outreach package to the SERs. On May 30 and 31, 2001, the Panel met with SERs to hear their comments on preliminary alternatives for regulatory flexibility and related information. The Panel also received written comments from the SERs in response to the discussions at this meeting and the outreach materials. The Panel asked SERs to evaluate how they would be affected under a variety of regulatory approaches, and to provide advice and recommendations regarding early ideas for alternatives that would provide flexibility to address their compliance burden.

SERs representing companies in each of the sectors addressed by the Panel raised concerns about the potential costs of complying with the rules under development. For the most part, their concerns were focused on two issues: (1) the difficulty (and added cost) that they would face in complying with certification requirements associated with the standards EPA is developing, and (2) the cost of meeting the standards themselves. SERs observed that these costs would include the opportunity cost of deploying resources for research and development, expenditures for tooling/retooling, and the added cost of new engine designs or other parts that would need to be added to equipment in order to meet EPA emission standards. In addition, in each category, the SERs noted that small manufacturers (and in the case of one category, small importers) have fewer resources and are therefore less well equipped to undertake these new activities and expenditures. Furthermore, because their product lines tend to be smaller, any additional fixed costs must be recovered over a smaller number of units. Thus, absent any provisions to address these issues, new emission standards are likely to impose much more significant adverse effects on small entities than on their larger competitors.

The Panel discussed each of the issues raised in the outreach meetings and in written comments by the SERs. The Panel agreed that EPA should consider the issues raised by the SERs and that it would be appropriate for EPA to propose and/or request comment on various alternative approaches to address these concerns. The Panel's key discussions centered around the need for and most appropriate types of regulatory compliance alternatives for small businesses. The Panel considered a variety of provisions to reduce the burden of complying with new emission standards and related requirements. Some of these provisions would apply to all companies (e.g., averaging, banking, and trading), while others would be targeted at the unique circumstances faced by small businesses. A complete discussion of the regulatory alternatives recommended by the Panel can be found in the Final Panel Report. Summaries of the Panel's recommended alternatives for each of the sectors subject to this action can be found in their respective sections of the preamble. The vast majority of the Panel recommendations were adopted by the Agency, and are being finalized as part of this rule, either as first-tier or second-tier flexibilities.

First-tier flexibilities provide the greatest flexibility for many small entities. These provisions are likely to be most valuable because they either provide more time for compliance (e.g., additional lead time and hardship provisions) or allow for certification of engines based on particular engine designs or certification to other EPA programs. We are adopting these provisions essentially as proposed.

Second-tier flexibilities have the potential to reduce near-term and even long-term costs once a small entity has a product it is preparing to certify. These are important in that the costs of testing multiple engine families, testing a fraction of the production line, and developing deterioration factors can be significant. Small businesses may also meet an emission standard on average or generate credits for producing engines that emit at levels below the standard; these credits can then be sold to other manufacturers for compliance or banked for use in future model years. We are adopting these provisions essentially as proposed.

8.6.1 General Provisions

The most universal of the first-tier flexibilities are the hardship provisions. These apply to all the categories of vehicles and engines covered by this rulemaking. The Panel recommended that we propose two types of hardship provisions. The first type allows small businesses to petition EPA for additional lead time (e.g., up to 3 years) to comply with the standards. To qualify, a small manufacturer must make the case that it has taken all possible business, technical, and economic steps to comply, but that the burden of compliance costs will have a significant impact on the company's solvency. A manufacturer must provide a compliance plan detailing when and how it will achieve compliance with the standards. Hardship relief may include requirements for reducing emission on an interim basis and/or purchasing and using emission credits. The length of the hardship relief decided during review of the hardship application may be up to one year, with the potential to extend the relief as needed. The second hardship program allows companies to apply for hardship relief if circumstances outside their control cause the failure to comply (i.e., supply contract broken by parts supplier) and if the failure to sell the subject engines will have a major impact on the company's solvency. We would, however, not grant hardship relief if contract problems with a specific company prevent compliance for a second time.

Since equipment manufacturers who don't manufacture their own engines depend on engine manufacturers to supply certified engines, there was a concern that these engines would not be received in time to produce complying equipment by the date emission standards take effect. We have heard of certified engines being available too late for equipment manufacturers to redesign their equipment for changing engine size or performance characteristics. To address this concern, equipment manufacturers may request up to one extra year before using certified engines if they are not at fault and will face serious economic hardship without an extension.

A second-tier of flexibility, the averaging, banking and trading (ABT) program is also almost universal in its applicability. Averaging programs allow a manufacturer to certify one or more engine families at emission levels above the applicable emission standards, provided that the increased emissions are offset by one or more engine families certified below the applicable standards. Adding an emission-credit program containing banking and trading provisions, allow manufacturers to generate emission credits for certifying below the standards, and bank them for future use in their own averaging program or sell them to another entity.

ABT programs are being finalized for all categories of vehicles and engines covered by this rule, except for Large SI engines. However, a simplified ABT variation, which we are calling "family banking," will allow Large SI manufactures to certify an engine family early, and then to delay certification of a comparable engine family to the Phase 1 standards. ABT provisions are not limited to small entities, but provide another flexibility for reducing the burden on these entities.

8.6.2 Nonroad recreational vehicles

As described above, the report of the Small Business Advocacy Review Panel addresses the concerns of small-volume manufacturers of recreational vehicles. To identify representatives of small businesses for this process, we used the definitions provided by the Small Business Administration for producers and importers of motorcycles, ATVs, and snowmobiles (fewer than 500 employees for manufacturers, 100 for importers). Eleven small businesses agreed to serve as small-entity representatives. These companies represented a cross-section of off-highway motorcycle, ATV, and snowmobile manufacturers, as well as importers of off-highway motorcycles and ATVs. We proposed to adopt the provisions recommended by the panel and received comments on the proposals. We are now finalizing the provisions below essentially as proposed, with the modifications noted below.

As noted above, permeation standards were not part of the original NPRM for this rule, which incorporated recommendations from the SBAR Panel process. When we reopened the comment period on May 1, 2002 to request comment on possible approaches to regulating permeation emissions from recreational vehicles, we did not specifically discuss small business issues. However, it was our intent that the proposed flexibilities for exhaust emissions should carry over to permeation controls for all three vehicle categories, to the extent that they are applicable, and we are finalizing these flexibilities for the permeation standards as well as for the exhaust standards. Thus, we are effectively extending the work of the SBAR panel to cover the permeation requirements in this final rule by including the flexibilities described below.

The following Panel recommendations apply to nonroad motorcycles, ATVs and snowmobiles. The Panel recommended that EPA restrict the flexibilities described below for off-road motorcycle and ATV engines to those produced or imported by small entities with combined annual sales of less than 5,000 units per model year. Because of the differences, both in numbers and production, between small snowmobile manufacturers and small ATV/off-road motorcycle manufacturers, the Panel recommended no maximum production limits for snowmobiles.

Additional lead time. The Panel recommended that EPA propose at least a two-year delay, but seek comment on whether a longer time period is appropriate given the costs of compliance for small businesses and the relationship between importers and their suppliers. This would provide additional time for small-volume manufacturers to revise their manufacturing process, and would allow importers to change their supply chain to acquire complying products. The Panel recommended that EPA request comment on the appropriate length for a delay (lead-time). We are finalizing a two year delay beyond the date that larger businesses must comply with the standards for the Phase 1, and (in the case of snowmobiles) Phase 2 and Phase 3 standards.

Design-based certification. The Panel recommended that EPA propose to permit small entities to use design certification. The Panel also recommended that EPA work with the small-entity representatives and other members of the industry to develop appropriate criteria for such design-based certification. We are finalizing this recommendation. Small-volume manufacturers may use design-based certification, which allows us to issue a certificate to a small business for the emission-performance standard based on a demonstration that engines or vehicles meet design criteria rather than by emission testing. The intent is to demonstrate that an engine using a design similar to or superior than that being used by larger manufacturers to meet the emission standards will ensure compliance with the standards. The demonstration must be based in part on emission test data from engines of a similar design. Under a design-based certification program, a manufacturer provides evidence in the application for certification that an engine or vehicle meets the applicable standards for its useful life based on its design (e.g., the use a four-stroke engine, advanced fuel injection, or any other particular technology or calibration). Design criteria might include specifications for engine type, calibrations (spark timing, air /fuel ratio, etc.), and other emission-critical features, including, if appropriate, catalysts (size, efficiency, precious metal loading). Manufacturers submit adequate engineering and other information about their individual designs showing that they will meet emission standards for the useful life.

Broaden engine families. The Panel recommended that EPA request comment on engine family flexibility, in addition to conducting design-based certification emissions testing. Under this provision, small businesses may define their engine families more broadly, putting all their models into one engine family (or more, as needed) for certification purposes. Manufacturers could then certify their engines using the “worst-case” configuration within the family. A small manufacturer who might need to conduct certification emission testing, rather than pursuing design-based certification, would likely find broadened engine families useful

Production-line testing (PLT) waiver. The Panel recommended that EPA propose to provide small manufacturers and small importers a waiver from manufacturer production line testing. The Panel also recommended that EPA request comment on whether limits or the scope of this waiver are appropriate. Under PLT, manufacturers must test a small sampling of production engines to ensure that production engines meet emission standards. We are waiving production-line testing requirements for small manufacturers. This waiver will eliminate production-line testing requirements for small businesses.

Use of assigned deterioration factors (DFs) for certification. The Panel recommended that EPA propose to provide small business with the option to use assigned deterioration factors. Small manufacturers may use DFs assigned by EPA. Rather than performing a durability demonstration for each family for certification, manufacturers may elect to use deterioration factors determined by us to demonstrate emission levels at the end of the useful life, thus reducing the development and testing burden. This might also be a very useful and cost-beneficial option for a small manufacturer opting to perform certification emission testing instead of design-based certification.

Using emission standards and certification from other EPA programs. A wide array of engines certified to other EPA programs may be used in recreational vehicles. For example, there is a large variety of engines certified to EPA lawn and garden standards (Small SI). The Panel recommended that EPA propose to provide small business with this flexibility through the fifth year of the program and request comment on which of the already established standards and programs are believed to be a useful certification option for the small businesses. We are accepting that recommendation. Manufacturers of recreational vehicles may use engines certified to any other EPA standards for five years. Under this approach, engines certified to the Small SI standards may be used in recreational vehicles, even though the recreational vehicle application may not be the primary intended application for the engine. These engines would then meet the Small SI standards and related provisions rather than those adopted in this document for recreational vehicles. Small businesses using these engines will not have to recertify them, as long as they do not alter the engines in a way that might cause it to exceed the emission standards it was originally certified to meet. Naturally, a small manufacturer may also use a comparable certified engine produced by a large manufacturer, as long as the small manufacturer did not change the engine in a way that might cause it to exceed the applicable emission standards. This provides a reasonable degree of emission control. For example, if a manufacturer changed a certified engine only by replacing the stock exhaust pipes with pipes of similar configuration or the stock muffler and air intake box with a muffler and air box of similar air flow, the engine would still be eligible for this flexibility option, subject to our review.

Averaging, banking, and trading (ABT). The Panel recommended that EPA propose to provide small business with the same ABT program flexibilities that would apply for large manufacturers and request comment on how the provisions could be enhanced for small business to make them more useful. For the overall program, we are adopting corporate-average emission standards with opportunities for banking and trading of emission credits. At first we expect the averaging provisions to be most helpful to manufacturers with broad product lines. Small manufacturers and small importers with only a few models might not have as much opportunity to take advantage of these flexibilities. However, we received comment from one small manufacturer supporting these types of provisions as a critical component of the program. Therefore, we are adopting corporate-average emission standards with opportunities for banking and trading of emission credits for small manufacturers.

8.6.2.1 Off-highway motorcycles and ATVs

In addition to ABT, EPA is finalizing other provisions that are not limited to small entities, but which could prove helpful to small businesses. Small entities could benefit from harmonization of the ATV standards with California emission standards since only one model, rather than two, would need to be certified to allow the product to be sold in all 50 states. Similarly, the 2 gram and the optional 4 gram HC +NOx emission standards for off-highway motorcycles could make it less costly for small entities to comply with the standards, in addition to their primary purposes of preventing product shortages and encouraging certification of competition bikes. The optional 4 gram HC + NOx standard in fact was suggested in the comments submitted by a small manufacturer. Finally, small ATV producers could benefit from the option of complying with engine-based emission standards using the SAE J1088 test procedure for three years. This flexibility could allow small entities to phase in major equipment purchases such as chassis dynamometers necessary to be able to run the Federal Test Procedure.

As stated earlier, we are applying the flexibilities outlined above in section 8.6.2 to engines produced or imported by small entities with combined off-highway motorcycle and ATV annual sales of fewer than 5,000 units. The SBAR Panel recommended these provisions to address the potentially significant adverse effects on small entities of an emission standard that may require conversion to four-stroke engines. The 5,000-unit threshold is intended to provide these flexibilities to those segments of the market where the need is likely to be greatest, and to ensure that the flexibilities do not result in significant adverse environmental effects during the period of additional lead-time recommended below. For example, some importers with access to large supplies of vehicles from major overseas manufacturers could substantially increase their market share by selling less expensive noncomplying products. In addition, we are limiting some or all of these flexibilities to companies that are in existence or have product sales at the time we proposed emission standards to avoid creating arbitrary opportunities in the import sector, and to guard against the possibility of corporate reorganization, entry into the market, or other action for the sole purpose of circumventing emission standards.

8.6.2.2 Snowmobiles

As in the case of off-highway motorcycles and ATVs, small snowmobile manufacturers may benefit from provisions set for both large and small manufacturers. Small entities could benefit from the pull ahead standards provision, whereby a manufacturer could certify to the Phase 2 standards and bypass the Phase 1 standards. There are special snowmobile ABT provisions that could also be helpful to small entities. The early credit provision, where manufacturers could generate credits by marketing clean snowmobiles earlier than 2006, and the elimination of FEL limits for Phase 1 are the prime examples. However, Even with these and the broad flexibilities for all recreational vehicles described above in section 8.6.2, there may be a situation where a small snowmobile manufacturer cannot comply. There are only a few small snowmobile manufacturers, who sell only a few hundred sleds a year, which represents less than 0.5 percent of total annual production. Therefore, the per-unit cost of regulation may be significantly higher for these small entities because they produce very low volumes. Additionally, these companies do not have the design and engineering resources to tackle compliance with emission standard requirements at the same time as large manufacturers and tend to have limited ability to invest the capital necessary to conduct emission testing related to research, development, and certification. Finally, some of the requirements of the snowmobile program may be infeasible or highly impractical because some small-volume manufacturers may have typically produced engines with unique designs or calibrations to serve niche markets (such as mountain riding). The new snowmobile emission standards may thus impose significant economic hardship on these few manufacturers whose market presence is small. We therefore believe significant additional flexibility for these small snowmobile manufacturers is necessary and appropriate, as described below.

Additional lead time. The Panel recommended that EPA propose to delay the standards for small snowmobile manufacturers by two years from the date when other manufacturers would be required to comply. The Panel also recommended that EPA propose that emission standards for small snowmobile manufacturers be phased in over an additional two years (four years to fully implement the standard). We are adopting these recommendations. The two-year delay noted above in the general provisions in section 8.6.1 also applies to the timing of the standards for snowmobiles. In addition, for small snowmobile manufacturers, the emission standards phase in over an additional two years at a rate of 50 percent, then 100 percent. Phase 1 thus phases in at 50/100 percent in 2008/2009, Phase 2 phases in at 50/100 percent in 2012/2013, and Phase 3 phases in at 50/100 percent in 2014/2015.

Unique snowmobile engines. The Panel recommended that EPA seek comment on an additional provision, which would allow a small snowmobile manufacturer to petition EPA for relaxed standards for one or more engine families. The Panel also recommended that EPA allow a provision for EPA to set an alternative standard at a level between the prescribed standard and the baseline level until the engine family is retired or modified in such a way as to increase emission and for the provision to be extended for up to 300 engines per year per manufacturer would assure it is sufficiently available for those manufacturers for whom the need is greatest. Finally, the Panel recommended that EPA seek comment on initial and deadline dates for the submission of such petitions. We received no comments in this area, but for clarity have decided to require at least nine months lead time by the petitioner.

In response to these recommendations and comments, we are adopting an additional provision to allow a small snowmobile manufacturer to petition us for relaxed standards for one or more engine families. The manufacturer must justify that the engine has unique design characteristics, calibration, or operating characteristics that make it atypical and infeasible or highly impractical to meet the emission-reduction requirements, considering technology, cost, and other factors. At our discretion, we may then set an alternative standard at a level between the prescribed standard and the baseline level, which would likely apply until the family is retired or modified in a way that might alter emissions. These engines will be excluded from averaging calculations. We proposed that this provision be limited to 300 snowmobiles per year. However, we received comment that this limit is too restrictive to be of much assistance to small businesses. Based on this comment we are adopting a limit for this provision of 600 snowmobiles per year.

8.6.3 Nonroad industrial engines

As is the case for nonroad recreational vehicles, some of the provisions not specifically targeted at small entities may ease the burden of compliance for them. For example, comments from equipment manufacturers, including small entities, have made it clear that some nonroad applications involve operation in severe environments that require the use of air-cooled engines, which rely substantially on enrichment to provide additional cooling relative to water-cooled engines. Severe-duty applications include concrete saws and concrete pumps, which are exposed to high levels of concrete dust and highly abrasive particles. At the richer air-fuel ratios, catalysts are able to reduce NOx emissions but oxidation of CO emissions is much less effective. As a result, we are adopting less stringent emission standards for these “severe-duty” engines. Manufacturers may request approval in identifying additional severe-duty applications subject to these less stringent standards based on the current use of air-cooled engines or some other engineering arguments showing that air-cooled engines are necessary for these applications. This arrangement generally prevents these higher-emitting engines from gaining a competitive advantage in markets that don’t already use air-cooled engines.

The SBAR Panel recommended that EPA propose several possible provisions to address concerns that the new EPA standards could potentially place small businesses at a competitive disadvantage to larger entities in the industry. Except as noted, we have adopted the specific Panel recommendations listed below.

<u>Using Certification and Emissions Standards from Other EPA Programs</u>. The Panel made several recommendations for this provision. First, the Panel recommended that EPA temporarily expand this arrangement to allow small numbers of constant-speed engines up to 2.5 liters (up to 30kW) to be certified to the Small SI standards. Second, the Panel further recommended that EPA seek comment on the appropriateness of limiting the sales level of 300. Third, the Panel recommended that EPA request comment on the anticipated cap of 30 kW on the special treatment provisions outlined above, or whether a higher cap on power rating is appropriate. Finally, the Panel recommended that EPA propose to allow small-volume manufacturers producing engines up to 30kW to certify to the small SI standards during the first 3

model years of the program. Thereafter, the standards and test procedures which could apply to other companies at the start of the program would apply to small businesses. We are not adopting this provision and are instead relying on the hardship provisions in the final rule, which will allow us to accomplish the objective of the proposed provision with more flexibility.

Delay of Emission Standards. The Panel recommended that EPA propose to delay the applicability of the long-term standards to small-volume manufacturers for three years beyond the date at which they would generally apply to accommodate the possibility that small companies need to undertake further design work to adequately optimize their designs and to allow them to recover the costs associated with the near-term emission standards. We are also folding this provision into the scope of the hardship provision, but believe it would be appropriate to allow up to four years delay, depending on need.

Production Line Testing. The Panel made several recommendations for this provision. First, the Panel recommended that EPA adopt provisions allowing more flexibility than is available under the California Large SI program or other EPA programs generally to address the concern that production-line testing is another area where small-volume manufacturers typically face a difficult testing burden. Second, the Panel recommended that EPA allow small-volume manufacturers to have a reduced testing rate if they have consistently good test results from testing production-line engines. Finally, the Panel recommended that EPA allow small-volume manufacturers to use alternative low-cost testing options to show that production-line engines meet emission standards.

Deterioration Factors. The Panel recommended that EPA allow small-volume manufacturers to develop a deterioration factor based on available emission measurements and good engineering judgement. We are adopting an approach that gives manufacturers wide discretion to establish deterioration factors for Large SI engines. The general expectation is that manufacturers will rely on emission measurements from engines have operated for an extended period, either in field service or in the laboratory. The manufacturer should do testing as needed to be confident that their engines will meet emission standards under the in-use testing program. However, we intend to rely on manufacturers' technical judgment and related data (instead of results from in-use testing) to appropriately estimate deterioration factors to protect themselves from the risk of noncompliance.

Hardship Provision. The Panel recommended that EPA propose two types of hardship provisions for Large SI engines. First the Panel recommended that EPA allow small businesses to petition EPA for additional lead time (e.g., up to 3 years) to comply with the standards. Second, the Panel recommended that EPA allow small businesses to apply for hardship relief if circumstances outside their control cause the failure to comply (i.e., supply contract broken by parts supplier) and if the failure to sell the subject engines would have a major impact on the company's solvency. We are adopting hardship provisions to address the particular concerns of small-volume manufacturers, which generally have limited capital and engineering resources. These hardship provisions are generally described in Section 8.6.1. For Large SI engines, we are adopting a longer available extension of the deadline, up to three years, for meeting emission standards for companies that qualify for special treatment under the hardship provisions. We will, however, not extend the deadline for compliance beyond the three-year period. This approach considers the fact that, unlike most other engine categories, qualifying small businesses are more likely to be manufacturers designing their own products. Other types of engines more often involve importers, which are limited more by available engine suppliers than design or development schedules.

8.6.4 Recreational marine diesel engines

Prior to the proposal, we conducted a Small Business Advocacy Review Panel. The panel process gathers input from small entities potentially affected by the new regulations. To identify small businesses representatives for this process, we used the Small Business Administration definitions for engine manufacturers and boat builders. We then contacted companies manufacturing internal-combustion engines employing fewer than 1,000 people to be small-entity representatives for the Panel. Companies selling or installing such engines in boats and employing fewer than 500 people were also considered small businesses for the Panel. Based on this information, we asked 16 small businesses to serve as small-entity representatives. These companies represented a cross-section of both gasoline and diesel engine marinizers, as well as boat builders. With input from small-entity representatives, the Panel drafted a report with findings and recommendations on how to reduce the potential small-business burden resulting from this rule. The Panel's recommendation's were proposed by EPA and are now being finalized essentially as proposed. Commenters generally supported these provisions. The following sections describe these flexibilities.

8.6.4.1 Engine Dressers

The manufacturers involved include engine dressers, small-volume engine marinizers, and small-volume boat builders. Many recreational marine diesel engine manufacturers modify new, land-based engines for installation on a marine vessel. Some of the companies that modify engines for installation in boats make no changes that might affect emissions. Their modifications may consist only of adding mounting hardware and a generator or reduction gears for propulsion. They may involve installing a new marine cooling system that meets original manufacturer specifications and duplicates the cooling characteristics of the land-based engine, but with a different cooling medium (i.e., sea water). In many ways, these manufacturers are similar to nonroad equipment manufacturers who purchase certified land-based nonroad engines to make auxiliary engines. This simplified approach of producing an engine can more accurately be described as dressing an engine for a particular application.

To clarify the responsibilities of engine dressers under this rule, we will exempt them from the requirement to certify engines to emission standards, as long as they meet the following seven conditions.

(1) The engine being dressed (the "base" engine) must be a highway, land-based nonroad, or locomotive engine, certified pursuant to 40 CFR part 86, 40 CFR part 89, or 40 CFR part 92, respectively, or a marine diesel engine certified pursuant to this part.

(2) The base engine's emissions, for all pollutants, must meet the otherwise applicable recreational marine emission limits. In other words, starting in 2005, a dressed nonroad Tier 1 engine will not qualify for this exemption, because the more stringent standards for recreational marine diesel engines go into effect at that time.

(3) The dressing process must not involve any modifications that can change engine emissions. We do not consider changes to the fuel system to be engine dressing, because this equipment is integral to the combustion characteristics of an engine. However, we are expanding the small-volume engine dresser definition to include water-cooled turbochargers where the goal is to match the performance of the non-water-cooled turbocharger on the original certified configuration. We believe this would provide more opportunities for diesel marinizers to be excluded from certification testing if they operate as dressers

(4) All components added to the engine, including cooling systems, must comply with the specifications provided by the engine manufacturer.

(5) The original emissions-related label must remain clearly visible on the engine.

(6) The engine dresser must notify purchasers that the marine engine is a dressed highway, nonroad, or locomotive engine and is exempt from the requirements of 40 CFR part 94.

(7) The engine dresser must report annually to us the models that are exempt pursuant to this provision and such other information as we deem necessary to ensure appropriate use of the exemption.

Any engine dresser not meeting all these conditions will be considered an engine manufacturer and will accordingly need to certify that new engines comply with this rule's provisions and label the engine, showing that it is available for use as a marine engine. An engine dresser violating the above criteria might also be liable under anti-tampering provisions for any change made to the land-based engine that affects emissions.

8.6.4.2 Small Diesel Engine Marinizers

The other small entities can be categorized as sterndrive and inboard engine marinizers, compression-ignition recreational marine engine marinizers, and boat builders that use these engines. We are providing additional flexibilities listed below for small-volume engine marinizers. The purpose of these flexibilities is to reduce the burden on companies who cannot distribute their fixed costs over a large number of engines. For this reason, we are defining a small-volume engine manufacturer based on annual U.S. sales of engines, and are providing the additional flexibilities on this basis, rather than on business size in terms of the number of employees, revenue, or other such measures. The production count we will use includes all engines (automotive, other nonroad, etc.), not just recreational marine engines. We consider recreational marine diesel engine manufacturers to be small volume for purposes of this provision if they produce fewer than 1,000 internal combustion engines per year. Based on our characterization of the industry, there is a natural break in production volumes just above the 500 engine sales mark. The next smallest manufacturers make tens of thousands of engines. We chose 1,000 engines as a limit because it groups together all the marinizers most needing relief, while still allowing for reasonable sales growth.

Delay Standards for Five Years. The Panel recommended that EPA delay the standards for five years for small businesses. We are concerned about the loss of emission control from part of the fleet during this time, but we recognize the special needs of small-volume marinizers and believe the added time may be necessary for these companies to comply with emission standards. This additional time will allow small-volume marinizers to obtain and implement proven, cost-effective emission-control technology. We are adopting the five-year delay; the standards will take effect from 2011 to 2014 for small-volume marinizers, depending on engine size. Marinizers may apply this five-year delay to all or just a portion of their production. Thus they may still sell engines that meet the standards where possible on some product lines, while delaying the introduction of emission-control technology on other product lines. This option provides more time for small marinizers to redesign their products, allowing time to learn from the technology development of the rest of the industry.

Design-Based Certification The Panel recommended that EPA allow manufacturers to certify by design and to be able to generate credits under this approach. The Panel also recommended that EPA provide adequately detailed design specifications and associated emission levels for several technology options that could be used to certify. Although we proposed this approach, we were unable to specify any technology options for diesel engines that could be used for a design-based certification. We requested comment on such designs and received no comment. Therefore, we are not finalizing a design-based certification option. However, as noted above, we are finalizing the engine dresser provisions and expanding these provisions to include water-cooled turbocharging. This will essentially allow some engines to be exempt from the standards based on design.

Broadly Defined Product Certification Families The Panel recommended that EPA take comment on the need for broadly defined emission families and how these families should be defined. We have established engine criteria for distinguishing between engine families which could result in a number of engine families for a manufacturer depending on the make-up of their product line. We are allowing small-volume marinizers to put all of their models into one engine family (or more as necessary) for certification purposes. Marinizers would then certify using the "worst-case" configuration. This approach is consistent with the option offered to post-manufacture marinizers under the commercial marine regulations. This approach has the advantage of minimizing certification testing, because the marinizer can use a single engine in the first year to certify their whole product line. As with large companies, the small-volume manufacturers could then carry-over certification data from year to year until they change their engine designs in a way that might significantly affect emissions.

Minimize compliance requirements. The Panel suggested we eliminate the compliance burden on small entities to the extent possible. As a result, we proposed to eliminate production-line and deterioration testing requirements for small-volume marinizers. We will assign a deterioration factor for use in calculating end-of-life emission factors for certification. The advantage of this approach is to minimize compliance testing.

Streamlined certification. The Panel recommended that EPA propose to specifically include NTE in a design-based approach. As noted above, we have concerns regarding a design-based approach. However, we will allow small-volume marinizers to certify to the not-to-exceed (NTE) requirements using a streamlined approach. We believe small-volume marinizers can make a satisfactory showing that they meet NTE standards with limited test data. Once these manufacturers test engines over the five-mode certification duty cycle (E5), they can use those or other test points to extrapolate the results to the rest of the NTE zone. For example, an engineering analysis may consider engine timing and fueling rate to determine how much the engine's emissions may change at points not included in the E5 cycle. For this streamlined NTE approach, keeping all four test modes of the E5 cycle within the NTE standards will be enough for small-volume marinizers to certify compliance with NTE requirements, as long as there are no significant changes in timing or fueling rate between modes.

Hardship provisions. The Panel recommended that EPA propose two types of hardship programs for marine engine manufacturers, boat builders and fuel tank manufacturers. First, that EPA should allow small businesses to petition EPA for additional lead time to comply with the standards. Second, that EPA should allow small businesses to apply for hardship relief if circumstances outside their control cause the failure to comply (i.e. supply contract broken by parts supplier) and if the failure to sell the subject fuel tanks or boats would have a major impact on the company's solvency. The Panel also recommended that EPA work with small manufacturers to develop these criteria and how they would be used.

We are adopting two hardship provisions for small-volume marinizers, who may apply for this relief on an annual basis. These are essentially the same provisions noted in section 8.6.1. First, small marinizers may petition us for additional time to comply with the standards. The marinizer must show that it has taken all possible steps to comply but the burden of compliance costs will have a major impact on the company's solvency. Also, if a certified base engine is available, the marinizer must generally use this engine. We believe this provision will protect small-volume marinizers from undue hardship due to certification burden. Also, some emission reduction can be gained if a certified base engine becomes available.

Second, small-volume marinizers may also apply for hardship relief if circumstances outside their control caused the failure to comply (such as a supply contract broken by parts supplier) and if failure to sell the subject engines will have a major impact on the company's solvency. We consider this relief mechanism to be an option of last resort. We believe this provision will protect small-volume marinizers from circumstances outside their control. We, however, intend to not grant hardship relief if contract problems with a specific company prevent compliance for a second time.

Although the panel did not specify a time limit for these hardship provisions, and we are not finalizing any such time limits, we envision these hardship provisions as transitional in nature. We would expect their use to be limited to the early years of the program, in a similar time frame as we are establishing for the recreational vehicle hardship provisions discussed above.

8.6.4.3 Small Recreational Boat Builders

The SBAR Panel Report also recommended approaches for reducing the burden on small-volume boat builders. The recommendations were based on the concerns that even though boat builders are not required to certify their own engines to the emission standards, they are required to use certified engines, and may need to redesign engine compartments on some boats if engine designs were to change significantly. EPA proposed the flexibilities recommended by the Panel and are finalizing them as proposed.

We are adopting four options for small-volume vessel manufacturers using recreational marine diesel engines. These options are intended to reduce the compliance burden on small companies which are not able to distribute their fixed costs over a large number of vessels. As proposed, we are therefore defining a small-volume boat builder as one that produces fewer than 100 boats for sale in the U.S. in one year and has fewer than 500 employees. The production count includes all engine-powered recreational boats. These options may be used at the manufacturer's discretion. The options for small-volume boat builders are discussed below.

<u>Percent-of-production delay.</u> Manufacturers with a written request from a small-volume boat builder and prior approval from us may produce a limited number of uncertified recreational marine diesel engines. From 2006 through 2010, small-volume boat builders may purchase uncertified engines to sell in boats in an amount equal to 80 percent of engine sales for one year.

For example, if the small boat builder sells 100 engines per year, a total of 80 uncertified engines may be sold over the five-year period. This will give small boat builders an option to delay using new engine designs for a portion of business. Engines produced under this flexibility must be labeled accordingly so that customs inspectors know which uncertified engines can be imported. We continue to believe this approach is appropriate and are finalizing it as proposed.

Small-volume allowance. This allowance is similar to the percent-of-production allowance, but is designed for boat builders with very small production volumes. The only difference with the above allowance is that the 80-percent allowance described above may be exceeded, as long as sales do not exceed either 10 engines per year or 20 engines over five years (2006 to 2010). This applies only to engines less than or equal to 2.5 liters per cylinder.

Existing inventory and replacement engine allowance. Small-volume boat builders may sell their existing inventory after the implementation date of the new standards. However, no purposeful stockpiling of uncertified engines is permitted. This provision is intended to allow small boat builders the ability to turn over engine designs.

Hardship relief provision. Small boat builders may apply for hardship relief if circumstances outside their control caused the problem (for example, if a supply contract were broken by the engine supplier) and if failure to sell the subject vessels will have a major impact on the company's solvency. This relief allows the boat builder to use an uncertified engine and is considered a mechanism of last resort. These hardship provisions are consistent with those currently in place for post-manufacture marinizers of commercial marine diesel engines.

8.7 Conclusion

EPA has conducted a substantial outreach program designed to gather information as to the effect of this final rule on small entities. This process has included two Small Business Advocacy Review Panels, which sought out small entities that would be affected by the rulemaking and obtained advice and recommendations from them as to ways in which to minimize the compliance burden placed upon them. We have also published an Advance Notice of Proposed Rulemaking and a Notice of Proposed Rulemaking which requested comments from the affected entities as well as from other interested parties in the public at large. Further, we have reopened the comment period to take comments on the permeation issue raised during the initial comment period, and have included permeation in the analysis of the effects of this rule on small entities. We have met with a number of stakeholders, including state and environmental organizations, engine manufacturers, and equipment manufacturers. From the information we have gathered during this process, as well as information provided by contractor studies, we have found that only 3 small entities are likely to be impacted by more than 3 percent of their sales, and estimate that the degree of impact is likely to be further reduced by the flexibilities that are being finalized in this rulemaking. EPA has thus determined that this final rule will not have a significant economic impact on a substantial number of small entities.

Chapter 9: Economic Impact Analysis

This chapter presents the economic impacts on the markets of the various vehicle categories affected by the emissions control program. Each category of vehicles is modeled separately. However the structure of the economic model used to estimate impacts is essentially the same. The first section of this chapter provides a summary of the economic impact results for each of the categories of vehicles affected by the rule. Next, we provide a general description of the economic theory used to estimate market impacts. We then discuss the concept of fuel efficiency gains resulting from the emissions control program and how they have been incorporated into the economic analysis. Also addressed is the potential for product attribute changes that may result due to the regulation. This is followed by a description of the methodology used to develop the economic model and the supply and demand elasticity estimates.

The remainder of the chapter takes each vehicle category in turn and describes the baseline market characterization, the per vehicle control costs of the regulation, the future years in which the costs are expected to be incurred, and the economic impact results generated from the model (excluding fuel efficiency gains). We compare the future year streams of engineering costs to the estimated economic welfare losses for each vehicle category for which the standards apply. Economic welfare loss is equal to the sum of the loss in consumer and producer surplus measures, excluding fuel efficiency gains. Last, we calculate a future year stream of social costs/gains by adding fuel cost savings to economic welfare losses and compare this stream to the stream of engineering costs of the rule (including fuel efficiency gains).

For each vehicle market, the economic model relies upon the most current year of data available (either the year 2000 or 2001) and examines the effect of the emissions control program as if the standards took effect in this year. The per engine control costs change over time as different phases of the standard are implemented and the learning curve is applied (see Chapter 5 for details concerning the learning curve). It is important to note that the per engine control costs reflect the variable cost and annual portion of capital cost associated with the regulations. To examine the effect of these cost changes, we calculate estimated impacts using baseline year price and output. This allows us to generate relative changes in prices and market quantities and compute losses in consumer and producer surplus. Price and quantity data from a baseline year are used rather than future year projections of prices and quantities because price projections for the future time stream are not available for the various vehicle markets, though quantity projections are.

As stated above, a future stream of welfare (or surplus) losses (excluding fuel cost savings) is calculated by summing of the losses of consumer and producer surplus. This stream of surplus losses, developed from baseline year price and quantity data, is compared to a hypothetical future stream of engineering costs that are calculated by multiplying the annual regulatory cost per vehicle in each year by the baseline year quantity. We calculate hypothetical engineering costs holding quantity constant so that we can make a valid comparison between the loss in surplus and engineering costs. The purpose of this comparison is to generate a surplus loss stream that accounts for projected changes in quantity.

Through our comparison, we develop an annual ratio of surplus loss to engineering costs, which is used to project the annual loss in surplus without fuel efficiency for the future year time stream (this projection is made by multiplying the annual ratio of surplus loss to engineering costs by the annual engineering costs shown in Chapter 7 for each vehicle category). The future stream of surplus losses differs from baseline estimates due to the projected growth in vehicle sales expected through the year 2030. Last, we calculate the future stream of annual social costs/gains by adding fuel cost savings to the projected loss in surplus and compare this stream of social costs/gains to the engineering costs accounting for fuel efficiency.

9.1 Summary of Economic Impact Results

An economic impact analysis of the emissions control program has been carried out to estimate its effects on the recreational diesel marine vessel, Large SI, snowmobile, ATV, and off-highway motorcycle markets. A summary of the economic impact results is presented in this section to show the relative changes in price and quantity and the future year streams of consumer and producer surplus losses (which exclude fuel cost savings), engineering costs, and social costs/gains (which include fuel cost savings) in each vehicle market. The net present value of the stream of surplus loss, fuel savings, and social costs/gains for each vehicle category is also presented. Discussions of the economic theory, methodology, and full estimation of the economic impacts are presented in the sections that follow. The results presented here for each vehicle category summarizes the full results provided in Section 9.6 through 9.10.

As mentioned above, the relative changes in price and quantity have been estimated for each vehicle category using the per vehicle costs as they change over future years. We calculate these economic impacts assuming baseline market price and quantity is the same as it was in the most current year for which data were available (year 2000 or 2001, depending on the vehicle category).

9.1.1 Summary Results for Marine

The focus of the diesel recreational marine vessel analysis is the market for diesel inboard cruisers. Based on discussions with industry representatives, inboard cruisers are the main type of recreational marine vessel equipped with diesel engines. Using a year 2001 baseline average market price of $341,945 (taken from data provided by the National Marine Manufacturers Association) and market quantity of 8,435 inboard cruisers (taken from EPA projections based on data from the National Marine Manufacturers Association), the future year stream of economic impacts were estimated for the changes in per marine vessel costs. These results are presented in Table 9.1-1.

As the table shows, the price and quantity changes are all less than one-quarter of a percent and by the year 2012, the relative price increase and quantity decrease are less than one-tenth of a percent. These impacts are considered minimal. Projected surplus losses are equal to over 99 percent of engineering costs for the diesel inboard cruiser market. The surplus losses are highest in the year 2010 (approximately $9.6 million), which coincides with the implementation of the second phase of the emissions control program for two of the three engine power classes affected by the rule. They fall to their lowest level (approximately $4.9 million) in the year 2014. They then steadily increase up through the year 2030. This trend of increased surplus losses occurs because a larger population of engines are projected further out into the future, hence a larger number of engines need to be controlled. Note that beyond the year 2010, loss in surplus of the rule for recreational diesel marine vessels are in the $5 to $7 million range. For the recreational diesel marine engine market, no fuel cost savings are projected. Therefore, the annual stream of surplus losses equals the social costs of the regulation for this vehicle category.

Table 9.1-1
Summary Economic Impact Results for the Diesel Inboard Cruiser Market

Year	Cost/unit ($)	Change in Price (%)*	Change in Quantity (%)*	Surplus Losses ($$10^3$)**	Engineering Costs ($$10^3$)	Social Costs ($$10^3$)***
2006	$808	0.12%	-0.18%	$7,795.3	$7,806.0	$7,795.3
2007	$844	0.13%	-0.19%	$8,350.3	$8,365.3	$8,350.3
2008	$844	0.13%	-0.19%	$8,558.2	$8,573.8	$8,558.2
2009	$905	0.14%	-0.20%	$9,398.8	$9,413.5	$9,398.8
2010	$905	0.14%	-0.20%	$9,621.7	$9,637.0	$9,621.7
2011	$478	0.07%	-0.10%	$5,203.9	$5,213.4	$5,203.9
2012	$464	0.07%	-0.10%	$5,165.6	$5,176.7	$5,165.6
2013	$464	0.07%	-0.10%	$5,279.4	$5,290.8	$5,279.4
2014	$426	0.06%	-0.09%	$4,952.0	$4,958.1	$4,952.0
2015	$426	0.06%	-0.09%	$5,056.6	$5,062.7	$5,056.6
2016	$426	0.06%	-0.09%	$5,161.4	$5,167.7	$5,161.4
2017	$426	0.06%	-0.09%	$5,266.2	$5,272.7	$5,266.2
2018	$426	0.06%	-0.09%	$5,371.2	$5,377.6	$5,371.2
2019	$426	0.06%	-0.09%	$5,476.0	$5,482.6	$5,476.0
2020	$426	0.06%	-0.09%	$5,580.8	$5,587.6	$5,580.8
2021	$426	0.06%	-0.09%	$5,685.5	$5,692.5	$5,685.5
2022	$426	0.06%	-0.09%	$5,790.3	$5,797.5	$5,790.3
2023	$426	0.06%	-0.09%	$5,895.3	$5,902.5	$5,895.3
2024	$426	0.06%	-0.09%	$6,000.1	$6,007.4	$6,000.1
2025	$426	0.06%	-0.09%	$6,104.9	$6,112.4	$6,104.9
2026	$426	0.06%	-0.09%	$6,209.7	$6,217.2	$6,209.7
2027	$426	0.06%	-0.09%	$6,314.3	$6,322.0	$6,314.3
2028	$426	0.06%	-0.09%	$6,419.0	$6,426.9	$6,419.0
2029	$426	0.06%	-0.09%	$6,523.6	$6,531.7	$6,523.6
2030	$426	0.06%	-0.09%	$6,628.4	$6,636.5	$6,628.4

*Percent change in price and quantity are based upon baseline market conditions for 2001
** Surplus Loss is equal to the sum of the loss in consumer surplus and producer surplus. This estimate reflects projected growth in vehicles occurring subsequent to the baseline year of 2001.
***Social Costs are equal to the surplus losses net fuel cost savings. For this vehicle category, there are no fuel cost savings; the future stream of surplus losses is therefore equal to the future stream of social costs. Cost estimates are based on 2001 dollars.

9.1.2 Summary Results for Large SI

As explained in Section 9.7, we performed an economic impact analysis for only the forklift segment of the Large SI market. A summary of the estimated changes in price and quantity, and the sum of consumer and producer surplus losses for forklifts is contained in Table 9.1-2. To estimate the total social costs/gains for Large SI, we use the engineering costs to approximate the sum of consumer and producer surplus losses for Large SI engines other than forklifts. This approach slightly overestimates the surplus losses for the category since engineering costs are higher than surplus losses.

The baseline year for the economic analysis of the forklift market is 2000. In this year, the forklift price is taken to be $26,380 (the price of a representative Class 5 forklift equipped with a Large SI engine) and the market output is equal to 65,000 forklifts (taken from the Power Systems Research (PSR) database). Based on these data, the relative changes in market price and output are calculated, as are the annual future year streams of surplus losses, engineering costs, and social costs/gains. Results are presented in Table 9.1-2.

Table 9.1-2
Summary Economic Impact Results for the Forklift Market

Year	Cost/unit ($)	Change in Price (%)*	Change in Quantity (%)*	Surplus Losses ($$10^3$)**	Engineering Costs ($$10^3$)	Social Costs/Gains ($$10^3$)***
2004	$610	0.75%	-1.12%	$43,823.1	$44,403.4	$6,724.8
2005	$610	0.75%	-1.12%	$44,996.9	$45,592.7	($29,708.1)
2006	$493	0.60%	-0.90%	$37,410.6	$37,816.0	($75,354.6)
2007	$537	0.66%	-0.98%	$41,745.3	$42,246.7	($108,221.4)
2008	$537	0.66%	-0.98%	$42,780.3	$43,294.1	($143,423.9)
2009	$418	0.51%	-0.77%	$34,194.5	$34,471.7	($187,187.5)
2010	$418	0.51%	-0.77%	$35,002.2	$35,286.0	($220,411.8)
2011	$418	0.51%	-0.77%	$35,809.9	$36,100.3	($248,987.1)
2012	$390	0.48%	-0.72%	$34,185.7	$34,447,5	($263,690.9)
2013	$390	0.48%	-0.72%	$34,939.8	$35,207.4	($273,632.9)
2014	$390	0.48%	-0.72%	$34,693.9	$35,967.3	($282,531.5)
2015	$390	0.48%	-0.72%	$36,448.0	$36,727.2	($290,434.8)
2016	$390	0.48%	-0.72%	$37,202.1	$37,487.0	($297,344.7)
2017	$390	0.48%	-0.72%	$37,956.2	$38,246.9	($303,835.7)
2018	$390	0.48%	-0.72%	$38,710.3	$39,006.8	($309,915.5)
2019	$390	0.48%	-0.72%	$39,464.3	$39,766.6	($315,594.1)
2020	$390	0.48%	-0.72%	$40,218.4	$40,526.5	($320,692.6)
2021	$390	0.48%	-0.72%	$40,972.5	$41,286.4	($325,792.0)

2022	$390	0.48%	-0.72%	$41,726.6	$42,046.3	($330,892.1)
2023	$390	0.48%	-0.72%	$42,480.7	$42,806.1	($336,421.4)
2024	$390	0.48%	-0.72%	$43,234.8	$43,566.0	($342,011.8)
2025	$390	0.48%	-0.72%	$43,988.9	$44,325.9	($347,604.0)
2026	$390	0.48%	-0.72%	$44,743.0	$45,085.7	($352,536.0)
2027	$390	0.48%	-0.72%	$45,497.1	$45,845.6	($357,472.3)
2028	$390	0.48%	-0.72%	$46,251.2	$46,605.5	($362,412.8)
2029	$390	0.48%	-0.72%	$47,005.3	$47,365.4	($367,356.6)
2030	$390	0.48%	-0.72%	$47,759.4	$48,125.2	($372,304.0)

*Percent change in price and quantity are based upon baseline market conditions for 2000
** Surplus Loss is equal to the sum of the loss in consumer surplus and producer surplus. This estimate reflects projected growth in vehicles occurring subsequent to the baseline year of 2000.
***Social Costs/Gains are equal to the surplus losses net fuel cost savings. ( ) represents a negative cost (social gain). Cost estimates are based upon 2000$.

The relative changes in price and quantity are slightly larger than they were for the inboard diesel cruiser market, but they are still considered minimal. The price and quantity changes resulting from the per forklift costs are less than 1 percent, with the exception of the quantity change during the two years of the rule's implementation. By the year 2014, the relative increase in market price is estimated to equal about one-half of one percent and the reduction in quantity is equal to approximately three-quarters of one percent. As the table shows, the annual surplus losses are approximately equal to 98 to 99 percent of engineering costs. Over the future year time stream presented, surplus losses range from a low of $34.2 million in 2009 to a high of $47.8 million in 2030.

An examination of the social costs/gains shows that the gains continually increase in the future. This growth in social gains arises from the increasing fuel savings over time. The initial growth in fuel savings can be attributed to the gradual turnover to new forklifts in the marketplace. After this turnover, the growth in fuel savings can be credited to an increase in the sales of forklifts. With a larger population of forklifts projected, the fuel savings are expected to be larger. Hence the rule, as it affects the forklift market, is expected to result in larger social gains as new forklifts enter the market and as more forklifts are purchased and operated in the future. In 2030, the social gains of the rule for this vehicle category are just over $370 million. Note that the figures discussed here and presented in the above table are not discounted.

Finally, to estimate the social costs/gains for the Large SI category as a whole, we can use engineering costs as an estimate for the sum of consumer and producer surplus losses. These estimates are contained in Table 9.1-3.

Table 9.1-3
Surplus Losses, Fuel Efficiency Gains,
and Social Gains/Costs for Large SI Engines in 2030[a]

Vehicle Category	Surplus Losses in 2030 ($$10^6$)	Fuel Efficiency Gains in 2030 ($$10^6$)	Social Gains/Costs in 2030[b] ($$10^6$)
Forklifts	$47.8	$420.1	$372.3
Other Large SI	$48.1	$138.4	$90.3
All Large SI	$95.9	$558.5	$462.6

[a] Figures are in 2000 dollars.
[b] Figures in this column exclude estimated social benefits.
[c] Figure is engineering costs; see text for explanation.
[d] Net Present Value is calculated over the 2002 to 2030 time frame using a 3 percent discount rate.

9.1.3 Summary Results for Snowmobiles

The baseline year for the economic analysis of the snowmobile market is 2001. In this year, the average snowmobile price is $6,360 and the market output is 140,629. These data are provided by the International Snowmobile Manufacturing Association (ISMA).[1] Based on these data, the relative changes in market price and output are calculated, as are the annual future year streams of surplus losses, engineering costs, and social costs or gains. Results are presented on Table 9.1-4.

Table 9.1-4
Summary Economic Impact Results for the Snowmobile Market

Year	Cost/unit ($)	Change in Price (%)*	Change in Quantity (%)*	Surplus Losses ($$10^3$)**	Engineering Costs ($$10^3$)	Social Costs/Gains ($$10^3$)***
2006	$35	0.28%	-0.56%	$6,546.9	$6,583.5	$6,155.4
2007	$69	0.56%	-1.11%	$13,397.7	$13,546.4	$12,172.3
2008	$65	0.52%	-1.05%	$13,047.2	$13,183.5	$10,577.4
2009	$65	0.52%	-1.05%	$13,316.0	$13,455.2	$9,568.5
2010	$185	1.49%	-2.98%	$37,787.2	$38,933.1	$28,241.7
2011	$181	1.46%	-2.92%	$37,571.1	$38,685.1	$21,937.4
2012	$239	1.92%	-3.85%	$49,981.9	$51,957.6	$24,916.0
2013	$239	1.92%	-3.85%	$50,697.2	$52,701.2	$15,841.0
2014	$202	1.63%	-3.25%	$43,852.8	$45.309.0	($1,007.1)
2015	$196	1.58%	-3.16%	$43,017.6	$44,402.3	($11,957.9)
2016	$182	1.47%	-2.93%	$40,648.1	$41,860.2	($24,397.9)

2017	$180	1.45%	-2.9%	$40,543.0	$41,738.4	($34,420.2)
2018	$180	1.45%	-2.9%	$41,003.0	$42,211.9	($43,542.9)
2019	$180	1.45%	-2.9%	$41,455.4	$42,677.6	($52,141.8)
2020	$180	1.45%	-2.9%	$41,903.1	$43,138.5	($60,276.2)
2021	$180	1.45%	-2.9%	$41,903.1	$43,138.5	($68,292.1)
2022	$180	1.45%	-2.9%	$41,903.1	$43,138.5	($74,761.8)
2023	$180	1.45%	-2.9%	$41,903.1	$43,138.5	($79,630.7)
2024	$180	1.45%	-2.9%	$41,903.1	$43,138.5	($83,278.1)
2025	$180	1.45%	-2.9%	$41,903.1	$43,138.5	($85,777.8)
2026	$180	1.45%	-2.9%	$41,903.1	$43,138.5	($87,804.8)
2027	$180	1.45%	-2.9%	$41,903.1	$43,138.5	($89,549.9)
2028	$180	1.45%	-2.9%	$41,903.1	$43,138.5	($91,022.3)
2029	$180	1.45%	-2.9%	$41,903.1	$43,138.5	($92,224.9)
2030	$180	1.45%	-2.9%	$41,903.1	$43,138.5	($93,165.9)

*Percent change in price and quantity are based upon baseline market conditions for 2001.
** Surplus Loss is equal to the sum of the loss in consumer surplus and producer surplus. This estimate reflects projected growth in vehicles occurring subsequent to the baseline year of 2001.
***Social Costs/Gains are equal to the surplus losses net fuel cost savings.
( ) represents a negative cost (social gain). Cost estimates are based upon 2001$

The relative increases in price expected to occur due to the rule range from 0.28 percent to 1.92 percent and reach a steady state level of 1.45 percent in 2015. The peak occurs in 2012 when the Phase III standards are implemented and the impacts decline with the recognition of learning curve effects. Estimated quantity changes follow a similar trend ranging from decreases of 0.56 percent to 3.85 percent in 2010 then reaching a steady state of 2.9 percent in 2017. It is important to note that these price quantity changes are based upon baseline 2001 snowmobile market conditions. As the table shows, the annual surplus losses are approximately equal to 96 to 99 percent of engineering costs. Over the future year time stream presented, surplus losses range from a low of $6.5 million in 2006 to a high of $50.7 million in 2012. These surplus losses account for projected growth in snowmobiles sales during the period.

An examination of the social costs and gains of the snowmobile regulation shows losses occur through 2013. Social gains begin in 2014 and continually increase in the future. This growth in social gains arises from the increasing fuel savings over time. The growth in fuel savings can be attributed to the gradual turnover of the snowmobile fleet to new fuel efficient technologies and to projected increases in the sales of snowmobiles. With a larger population of snowmobiles projected, the fuel savings are expected to be larger. Hence the rule, as it affects the snowmobile market, is expected to result in larger social gains as new snowmobiles enter the market and as more snowmobiles are purchased and operated in the future. In 2030, the social gains of the rule for this vehicle category are anticipated to be just over $93.0 million. Note that the figures discussed here and presented in the above table are not discounted and reflect 2001$.

9.1.4 Summary Results for ATVs

The baseline year for the economic analysis of the ATV market is 2001. In this year, the average ATV price is estimated to be $5,123 and the market output is equal to 880,000, this data was provided by MIC. Based on these data, the relative changes in market price and output are calculated, as are the annual future year streams of surplus losses, engineering costs, and social costs/gains. Results are presented in Table 9.1-5.

Table 9.1-5
Summary Economic Impact Results for the ATV Market

Year	Cost/unit ($)	Change in Price (%)*	Change in Quantity (%)*	Surplus Losses ($$10^3$)**	Engineering Costs ($$10^3$)	Social Costs/Gains ($$10^3$)***
2006	$43	0.28%	-0.56%	$42,186.6	$42,463.9	$41,252.7
2007	$82	0.53%	-1.07%	$80,258.8	$80,270.6	$76,563.7
2008	$78	0.51%	-1.02%	$75,611.8	$76,518.0	$68,657.0
2009	$71	0.46%	-0.92%	$69,529.4	$70,287.0	$58,605.5
2010	$66	0.43%	-0.86%	$64,681.3	$65,302.2	$49,541.9
2011	$57	0.37%	-0.74%	$55,891.6	$56,379.5	$36,400.4
2012	$53	0.34%	-0.69%	$52,019.5	$52,441.5	$28,143.4
2013	$53	0.34%	-0.69%	$52,019.5	$52,441.5	$23,830.7
2014	$53	0.34%	-0.69%	$52,019.5	$52,441.5	$19,705.2
2015	$53	0.34%	-0.69%	$52,019.5	$52,441.5	$15,801.2
2016	$51	0.33%	-0.66%	$49,612.0	$49,999.1	$9,780.7
2017	$48	0.31%	-0.62%	$47,210.3	$47,556.8	$4,086.6
2018	$48	0.31%	-0.62%	$47,210.3	$47,556.8	$1,360.2
2019	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($456.0)
2020	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($1,630.4)
2021	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($2,429.8)
2022	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($2,924.0)
2023	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($3,298.2)
2024	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($3,580.7)
2025	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($3,790.0)
2026	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($3,942.6)
2027	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($4,054.2)
2028	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($4,132.9)
2029	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($4,189.3)
2030	$48	0.31%	-0.62%	$47,210.3	$47,556.8	($4,227.9)

*Percent change in price and quantity are based upon baseline market conditions for 2001
** Surplus Loss is equal to the sum of the loss in consumer surplus and producer surplus. This estimate reflects projected growth in vehicles occurring subsequent to the baseline year of 2001.
***Social Costs/Gains are equal to the surplus losses net fuel cost savings. ( ) represents a negative cost (social gain). Cost estimates are based upon 2001$

The relative changes in price and quantity resulting from the ATV regulations are considered minimal. The anticipated price change increases resulting from the per ATV costs are 0.53 percent or less. The quantity change decreases resulting from the engine modification costs are 1 percent or less. As the table shows, the annual surplus losses are approximately equal to 98 to 99 percent of engineering costs. Over the future year time stream presented, surplus losses range from a low of $42.2 million in 2006 to a high of $80.3 million in 2007 and reach a steady state of $47.2 million in 2017.

An examination of the social costs/gains shows that the losses decrease beginning in 2008 and become gains in 2019 with gains continually increasing in the future through 2030. This growth in social gains arises from the increasing fuel savings over time. The initial growth in fuel savings can be attributed to the gradual conversion of ATVs to new fuel saving technologies in the marketplace. After this turnover, the growth in fuel savings can be credited to an increase in the sales of ATVs. With a larger population of ATVs projected, the fuel savings are expected to be larger. Hence the rule, as it affects the ATV market, is expected to result in larger social gains as new ATVs enter the market and as more ATVs are purchased and operated in the future. In 2030, the social gains of the rule for this vehicle category are just over $4.2 million. Note that the figures discussed here and presented in the above table are not discounted and reflect 2001$.

9.1.5 Summary Results for Off-Highway Motorcycles

The baseline year for the economic analysis of the off-highway motorcycle market is 2001. In this year, the average off-highway motorcycle price is estimated to be $2,253 and the market sales are equal to195,250 off-highway motorcycles. These data were provided by MIC. Based on these data, the relative changes in market price and output are calculated, as are the annual future year streams of surplus losses, engineering costs, and social costs/gains. Results are presented in Table 9.1-6.

Table 9.1-6
Summary Economic Impact Results for the Off-Highway Motorcycle Market

Year	Cost/unit ($)	Change in Price (%)*	Change in Quantity (%)*	Surplus Losses ($$10^3$)**	Engineering Costs ($$10^3$)	Social Costs/Gains ($$10^3$)***
2006	$79	1.11%	-2.23%	$15,840.8	$16,269.1	$15,207.4
2007	$155	2.18%	-4.37%	$30,551.2	$32,215.0	$28,489.4

2008	$143	2.01%	-4.03%	$28,424.3	$29,846.5	$24,658.7
2009	$128	1.80%	-3.61%	$25,970.3	$27,127.3	$20,302.3
2010	$117	1.65%	-3.30%	$23,984.8	$24,957.7	$16,332.2
2011	$102	1.44%	-2.87%	$21,328.9	$22,079.4	$11,658.7
2012	$99	1.39%	-2.79%	$20,895.5	$21,630.7	$9,242.8
2013	$99	1.39%	-2.79%	$21,104.4	$21,847.0	$7,551.0
2014	$99	1.39%	-2.79%	$21,315.5	$22,065.4	$5,910.8
2015	$99	1.39%	-2.79%	$21,528.6	$22,508.9	$4,332.7
2016	$99	1.39%	-2.79%	$21,743.9	$22,734.0	$2,893.5
2017	$99	1.39%	-2.79%	$21,961.4	$22,961.4	$1,757.2
2018	$99	1.39%	-2.79%	$22,181.0	$22,961.4	$1,039.5
2019	$99	1.39%	-2.79%	$22,402.8	$23,191.0	$609.1
2020	$99	1.39%	-2.79%	$22,626.8	$23,422.9	$325.0
2021	$99	1.39%	-2.79%	$22,853.1	$23,657.1	$119.2
2022	$99	1.39%	-2.79%	$23,081.6	$23,893.7	($35.0)
2023	$99	1.39%	-2.79%	$23,312.4	$24,132.6	($133.4)
2024	$99	1.39%	-2.79%	$23,545.6	$24,374.0	($195.4)
2025	$99	1.39%	-2.79%	$23,781.6	$24,617.7	($240.6)
2026	$99	1.39%	-2.79%	$24,018.0	$24,863.9	($256.0)
2027	$99	1.39%	-2.79%	$24,259.0	$25,112.2	($252.0)
2028	$99	1.39%	-2.79%	$24,501.6	$25,363.7	($244.9)
2029	$99	1.39%	-2.79%	$24,746.6	$25,617.3	($214.4)
2030	$99	1.39%	-2.79%	$24,994.1	$25,873.5	($170.7)

*Percent change in price and quantity are based upon baseline market conditions for 2001
** Surplus Loss is equal to the sum of the loss in consumer surplus and producer surplus. This estimate reflects projected growth in vehicles occurring subsequent to the baseline year of 2001.
***Social Costs/Gains are equal to the surplus losses net fuel cost savings. ( ) represents a negative cost (social gain). Cost estimates are based upon 2001$

The anticipated price change increases resulting from the engine modification costs range from 1.11 percent to 2.18 percent and reach a steady state of 1.39 percent in 2012. The quantity change decreases resulting from the per off-highway motorcycle costs range from 2.23 percent to 4.37 percent and reach a steady state of 2.79 percent in 2012. As the table shows, the annual surplus losses are approximately equal to 98 to 99 percent of engineering costs. Over the future year time stream presented, surplus losses range from a low of $15.8 million in 2006 to a high of $30.6 million in 2007.

An examination of the social costs/gains shows that the social costs reach a peak in 2007 and diminish annually through 2021. In 2020, annual social gains occur for this rule and annual gains occur through 2030. This diminishing social cost and increasing social gain arise from the increasing fuel savings over time. The initial growth in fuel savings can be attributed to the gradual conversion of off-highway motorcycles new fuel saving technologies in the marketplace. Hence the rule, as it affects the off-highway motorcycle market, is expected to result in larger social gains as new off-highway motorcycles enter the market and as more off-highway motorcycles are purchased and operated in the future. In 2030, the social gains of the rule for this vehicle category are $170,700. Note that the figures discussed here and presented in the above table are not discounted and reflect 2001$.

9.1.6 Net Present Value of Surplus Loss, Fuel Cost Savings, and Social Costs/Gains

For each of the vehicle categories, the net present value of the future streams of surplus losses, fuel savings, and social costs/gains have been calculated. The net present values of these future streams are calculated using a 3 percent discount rate and are calculated over the 2002 to 2030 time frame. We also show this information using a 7 percent discount rate. Table 9.1-7 presents the net present values and the surplus loss, fuel savings, and social costs/gains for the year 2030 for each of the vehicle categories.

Table 9.1-7
Year 2030 and Net Present Values of Surplus Losses, Fuel Cost Savings, and Social Costs/Gains ($million)[A]

Vehicle Category	Surplus Loss in 2030	NPV of Surplus Loss[B]	NPV of Surplus Loss[C]	Fuel Cost Savings in 2030	NPV of Fuel Cost Savings[B]	NPV of Fuel Cost Savings[C]	Social Costs/Gains in 2030[D]	NPV of Social Costs/Gains[B,D]	NPV of Social Costs/Gain[C,D]
CI Marine	$6.6	$99.6	$59.0	$0.0	$0.0	$0.0	$6.6	$99.6	$59.0
Forklifts	$47.8	$692.2	$415.8	$420.1	$4,883.4	$2,644.2	($372.3)	($4,191.2)	($2,228.4)
Other Large SI[E]	$48.1	$698.4	$419.7	$138.4	$1,494.4	$804.8	($90.3)	($796.0)	($385.1)
Snowmobiles	$41.9	$553.1	$296.9	$135.0	$999.6	$459.7	($93.1)	($446.5)	($162.8)
ATVs	$47.2	$829.2	$491.9	$51.4	$510.5	$253.0	($4.2)	$318.7	$238.9
Off-Highway Motorcycles	$25.0	$358.9	$206.2	$25.2	$242.4	$120.6	($0.2)	$116.5	$85.6
Total	$216.6	$3,231.4	$1,889.5	$770.1	$8,130.3	$4,282.3	($553.5)	($4,898.9)	($2,392.8)

[A] Figures are in year 2000 and 2001 dollars, depending on the vehicle category. ( ) represents a negative cost (social gain).
[B] Net Present Values are calculated using a discount rate of 3 percent over the 2002 - 2030 time period.
[C] Net Present Values are calculated using a discount rate of 7 percent over the 2002 - 2030 time period.
[D] Figures in this column do not include human health and environmental benefits of the regulations.
[E] Figures in this row are engineering cost estimates. See Section 9.7.6.

9.2 Economic Theory

Economic theory is based on the examination of choice behavior. As market conditions change, producers and consumers alter their production and purchasing decisions. In essence, this approach models the expected reallocation of society's resources in response to a regulation. The behavioral approach explicitly models the changes in market prices and production. These changes can be used to compute other impact variables, such as changes in producer and consumer surplus, changes in employment, and total changes in economic welfare. EPA relies heavily on this approach to develop impacts for the economic analysis. In order to develop a methodological approach to examine the economic impacts of the emissions standards applied to diesel recreational marine vessels, forklifts, and recreational vehicles, certain issues such as the model scope and length of run for the analysis must be considered. These concepts are discussed in detail here and can also be found in the OAQPS Economic Analysis Resource Document[2].

9.2.1 Partial vs. General Equilibrium Model Scope

A partial equilibrium market model examines the effect of a regulatory action on a single market, ignoring all other possible market interactions. Such an approach is justified in cases where a regulation's effect is expected to be concentrated in one market sector (i.e., the effect of the regulation in indirectly affected markets is relatively small). Other times this approach is used because of the difficulties of acquiring data for indirectly affected markets.

A general equilibrium market model tracks the effects of a regulation in all sectors of the economy. In this case, all inter-sectoral linkages are accounted for and examined. It is often difficult to examine every effect of a regulation on every market. Many market models therefore examine the most important linkages between sectors of the economy. These are generally referred to as "general" equilibrium models or multi-market partial equilibrium models.

For the analysis of the recreational vehicles emission standards, we rely upon a partial equilibrium market model to examine the economic impacts on the markets of each affected vehicle category. This choice was made because most of the economic impacts are expected to be incurred in the directly affected market and because of data availability issues.

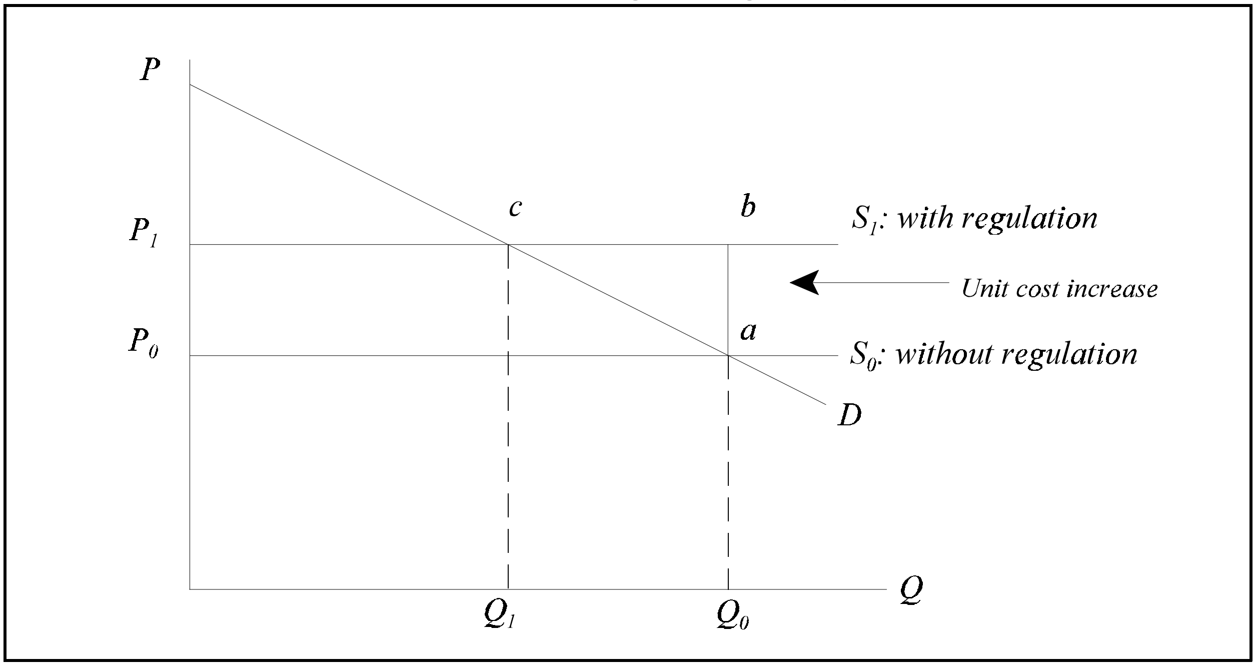
9.2.2 Length-of-Run Considerations

In developing the partial equilibrium model for this analysis, the choices available to producers must be considered. The choices are largely dependent upon the time horizon for which the analysis is performed. Three benchmark time horizons are presented here: the very short run, the long run, and the intermediate run. For this analysis, we focus on the partial quilibrium intermediate run analysis. Though these horizons refer to different lengths of time, they will likely differ depending upon the market in question. What defines these time horizons is the set of options or degree of flexibility producers have to respond to changing market conditions.

In the very short run, all factors of production are assumed to be fixed, thus leaving the directly affected entity with no means to respond. Within a short time horizon, regulated producers are unable to adjust inputs or outputs due to contractual, institutional, or other factors. In this scenario, the impacts of the regulation fall entirely on the regulated entities. Producers in this case incur the entire regulatory burden as a one-to-one reduction in their profit. This is often referred to as the “full-cost absorption” scenario.

In the long run, all factors of production are variable and producers can be expected to adjust their production plans in response to changes in cost resulting from a regulation. Entry and exit of firms into the industry is feasible. Figure 9.2-1 illustrates one example of a typical, if somewhat simplified, long-run supply function. In this example, the supply curve is horizontal, indicating that the marginal and average costs of production are constant with respect to output. This horizontal slope reflects the fact that, under long-run constant returns to scale, technology and input prices ultimately determine the market price, not the level of output in the market. Industry long run supply curves may exhibit constant, increasing, or decreasing returns to scale even in perfectly competitive markets. In many industries expansion of production in the long run may bid input prices up leading to increasing returns to scale. Constant returns to scale are assumed for illustrative purposes.

Figure 9.2-1
Full-Cost Pass Through of Regulatory Costs

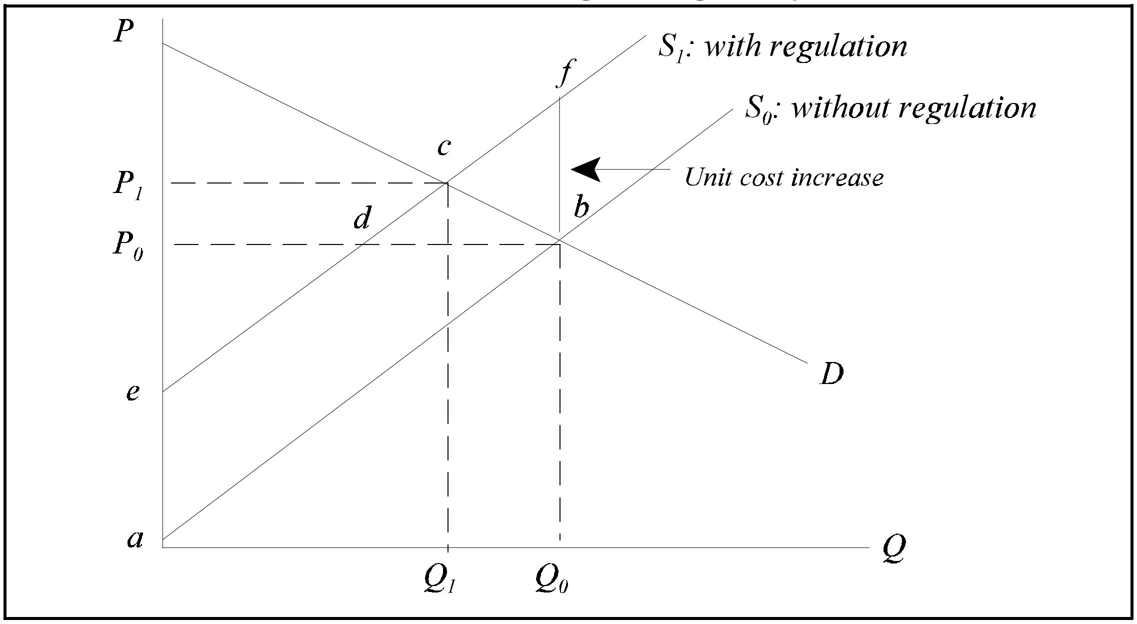


Market demand is represented by the standard downward-sloping curve. A constant cost industry is assumed; equilibrium is determined by the intersection of the supply and demand curves. In this case, the upward parallel shift in the market supply curve represents the regulation's effect on production costs. The shift causes the market price to increase by the full amount of the per-unit control cost (i.e., from P_0 to P_1). With the quantity demanded sensitive to price, the increase in market price leads to a reduction in output in the new with-regulation equilibrium (i.e., Q_0 to Q_1). As a result, consumers incur the entire regulatory burden as represented by the loss in consumer surplus (i.e., the area P_0acP_1). In the nomenclature of EIAs, this long-run scenario is typically referred to as "full-cost pass-through."

The "intermediate" run can best be defined by what it is not. It is not the very short run and it is not the long run. In the intermediate-run, some factors are fixed; some are variable. The existence of fixed production factors generally leads to diminishing returns to those fixed factors. This typically manifests itself in the form of a marginal cost function (which occupies the same locus of points as the supply curve) that rises with the output rate, as shown in Figure 9.2-2.

Again, the regulation causes an inward shift in the supply function due to the increase in production costs. The lack of resource mobility may cause profit (producer surplus) losses for producers in the face of regulation. However, unlike the full-cost absorption scenario, producers are able to pass through the associated costs to consumers to the extent the market will allow. As shown, in this case, the market-clearing process generates an increase in price (from P_0 to P_1) that is less than the per-unit increase in costs (fb), so that the regulatory burden is shared by producers (net reduction in profits) and consumers (rise in price). In this case, the change in consumer surplus is equal to P_0cbP_1. Producer surplus is equal to an increase in revenues on units it had previously sold prior to the cost increase (P_1cdP_0) and a loss due to the costs per unit they now face (area edba). The producer surplus is therefore equal to area edba - P_1cdP_0. The combined consumer and producer surplus loss is equal to P_1cdP_0 - P_1cbP_0 - edba. This is represented by area ecba and is referred to throughout this analysis as the surplus loss.

Figure 9.2-2
Partial-Cost Pass-Through of Regulatory Costs



As mentioned earlier, the economic analysis for each vehicle category focuses on an intermediate run approach. This is justified as the supply curve for each vehicle category shifts inwards by the total annualized cost per vehicle, not simply variable costs. Though this rule goes into effect over a number of years, there is a loss in economic welfare that is distributed across producers and consumers as the rule goes into effect. The analysis presented here chooses to focus on this loss in surplus and how it affects producers and consumers. Even if we were to take a long-run approach, the industry supply curve for each vehicle category may not be horizontal, (and thus represent a constant-cost industry). In fact, in many industries an increasing-cost industry might be the norm as the prices of factors of production are bid upwards as these industries expand.

9.3 Fuel Efficiency Gains

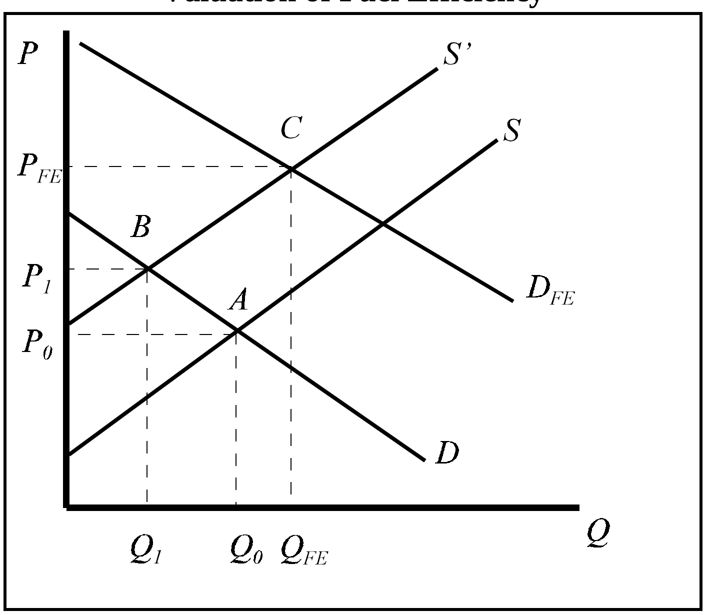
The main purpose of the emissions control program is to reduce emissions. However the changes made to the engines in forklifts, snowmobiles, ATVs, and off-highway motorcycles are also expected to result in fuel cost savings over the lifetime operation of these vehicles. Though the prices of these vehicles are expected to increase due to the regulatory costs imposed, consumers will spend less on fuel to operate the vehicles than they would have had the emissions control program not been implemented. This reduced spending on fuel is a benefit to consumers. This section qualitatively discusses the market impacts and welfare gains that may result from the savings in fuel costs.

When recreational vehicle and large SI engine producers are required to meet the emissions standard, they face an increase in the cost of production. This production cost increase causes an inward shift of the supply curve equal to the regulatory cost per vehicle, shown in Figure 9.2-2. As discussed earlier in Section 9.2.2, this leads to a loss in economic welfare equal to the sum of the loss in producer surplus and consumer surplus. What is not accounted for in Figure 9.2-2, however, is how fuel cost savings might affect the market equilibrium and what surplus gain is reaped from the improved fuel efficiency. Consumers may or may not incorporate the fuel efficiency gains into their valuation of a particular vehicle and the extent to which they do affects the market equilibrium quantity and price, surplus changes, and social costs.

If consumers value the improvement in fuel efficiency of a particular recreational vehicle, their demand curve for this product will shift out. The degree to which demand shifts reflects the magnitude of the potential fuel cost savings, the costs of being informed about the savings, and consumer time preferences. It may be the case that consumers are unaware of the fuel cost savings, that they don't perceive them to be as large as they are, or that they heavily discount their value. In those cases, there may be little or no shift in demand. Larger shifts in demand are expected if consumers face low information costs and/or have a low discount rate for the future savings in fuel costs.

For demonstration purposes, we can examine the hypothetical market for snowmobiles depicted in Figures 9.3-1 through 9.3-3 to see how market equilibrium price and quantity (point A) may change in response to the emissions control program and the fuel cost savings it generates. It is important to note that this discussion applies to all vehicle categories affected by the rule and the snowmobile market is used for explanatory purposes. This entails an examination of the changes in both supply and demand. Looking at Figure 9.3-1, assume that the net present value (NPV) of fuel cost savings per vehicle exceeds the regulatory control costs per snowmobile. As described above, the increase in the costs of producing snowmobiles results in a parallel shift inward of the supply curve. This leads to a higher price (P_1) and lower quantity (Q_1) sold, resulting in a new equilibrium point B. Now however, snowmobiles can operate using less fuel due to the technology advancements that are adopted to reduce emissions. This change in attribute may result in an outwards shift of the demand curve. If consumers fully value the fuel cost savings, demand will shift out to D_{FE}. The new equilibrium price (P_{FE}) and quantity (Q_{FE}) is represented by point C, which exceeds the market equilibrium price (P_0) and quantity (Q_0) before the emissions control program was adopted (point A). If producers were certain that consumers would fully value the fuel efficiency attribute, this change in technology may have occurred without the implementation of the regulation. If consumers and producers view the world in this manner, this scenario appears to be a market failure. What appears to be a win-win situation for consumers and producers does not occur in the market place absent regulation. The risk of producing new technology engines is borne by the producer as it is the producer that incurs the increased production costs. In contrast, fuel efficiency gains are experienced by the consumer to the extent the consumer is willing to pay the higher initial purchase price to gain fuel efficiency over the useful life of the vehicle. Producers offering the new technologies only gain from the new technology investment to the extent consumer's demand increases (demand curve shifts outward) sufficiently to offset the increased cost of production. Thus investment in the new fuel efficient technologies does represent a business risk for the producer and issues such as risk aversion may enter into the decision to introduce these newer, cleaner, and fuel efficient technologies into the marketplace absent regulatory requirements. As is depicted by the next two scenarios, perfect information does not exist regarding consumers preferences for fuel efficiency. Thus absent regulation, producers are making expenditures with uncertain potential for returns.

Figure 9.3-1
New Equilibrium with Full Consumer Valuation of Fuel Efficiency



If consumers do not fully value the fuel cost savings resulting from the regulation, demand may not shift out to D_{FE}, but instead shift to D'. As Figure 9.3-2 shows, market equilibrium is now represented by point D where new equilibrium market price (P_2) exceeds the original market price (P_0). However, the new equilibrium quantity (Q_2) is lower than the original equilibrium quantity (Q_0). In such a scenario, consumers do value the attribute somewhat and are willing to pay an increased price for the fuel efficient vehicles. However the price consumers are willing to pay does not fully compensate the producers for the cost of making the vehicle modification. In this scenario, it is likely that producers will be unwilling to make the engine technology improvements absent regulation.

Another possibility is that demand may not shift at all if consumers do not perceive the fuel cost savings associated with the new technology. In this case, Figure 9.3-3 represents the market outcome. In this final scenario consumers do not value fuel efficiency for these vehicles and, there is no profit motivation for producer to implement the technology changes absent regulation.

Figure 9.3-2
New Equilibrium With Partial Consumer Valuation of Fuel Efficiency

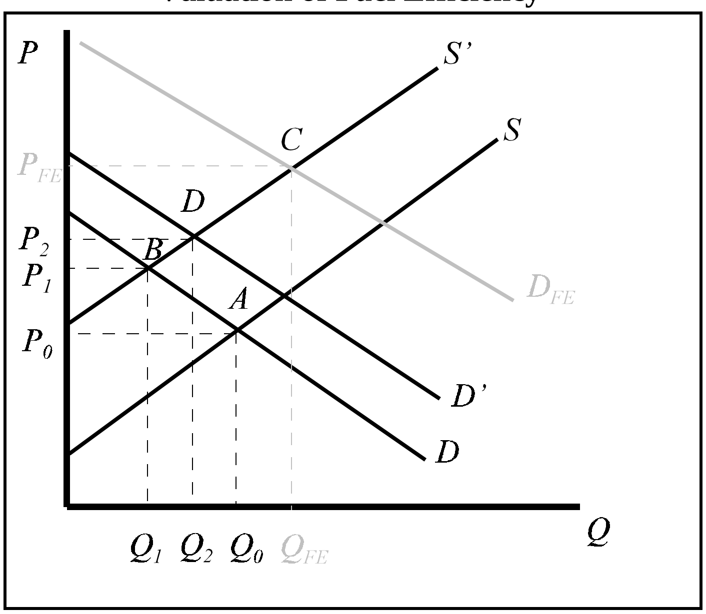
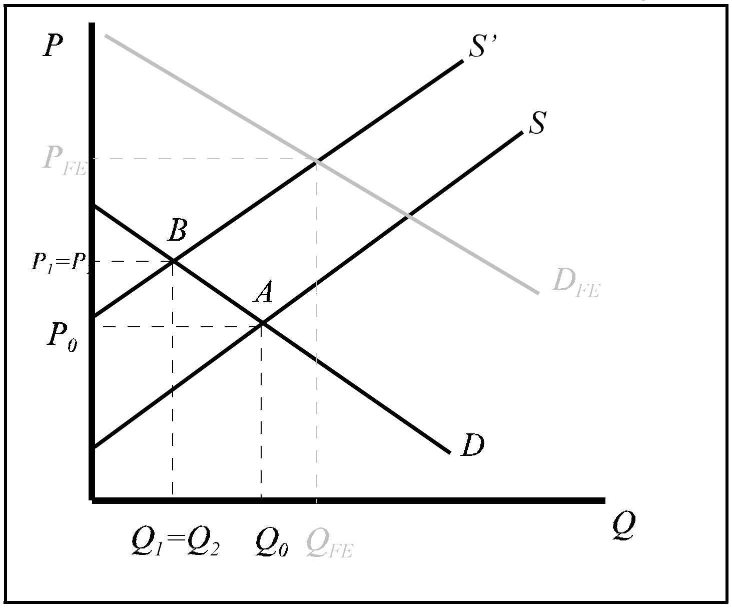


Figure 9.3-3
New Equilibrium with
No Consumer Valuation of Fuel Efficiency



It is important to recognize that the new price and quantity in the market for snowmobiles is determined by both a shift in supply as the cost of producing snowmobiles increases and a shift in demand to account for consumers' valuation of fuel cost savings. The potential gains to producers from making engine technology changes that increase fuel efficiency are uncertain and provide an explanation as to why these changes have not occurred in some recreational vehicle markets absent regulation.

Another effect not depicted in the graphs above occurs in the fuel or gasoline market where consumers now demand a smaller quantity of fuel to operate the fuel efficient vehicles. Since consumers will now require less fuel to operate snowmobiles than would be required absent the regulation, there is an inward shift in demand for gasoline. This shift in demand will likely be so small as to not affect the price of fuel since consumers of large SI engine equipment and recreational vehicles are a small segment of the total gasoline market. However, consumers experience a gain equal to the NPV of the change in the quantity of fuel consumed multiplied by the price of fuel over the lifetime of the vehicle. This is taken to equal the fuel cost savings for each vehicle category as calculated and presented in Chapter 7. This gain occurs independently of consumer preferences for fuel efficient vehicles. Specifically, if a consumer chooses to purchase a more fuel efficient vehicle, the consumer will experience the gain of increased fuel cost savings while using the product regardless of his or her preference for the fuel efficient attributes of the vehicle.

For this analysis, we are uncertain of the size of the outward shift in demand. We therefore do not project the price and quantity changes that occur taking fuel savings into account. However, we do account for the fuel cost savings by subtracting it from the surplus losses of the rule for each vehicle category over the future year time stream to generate a more accurate assessment of the social costs/gains of the regulation. The annual fuel efficiency gains are projected for each vehicle category in the future as described in Chapter 7 and appropriately consider the fleet of fuel efficient vehicles operating annually through 2030 and expected vehicle usage. The fuel efficiency gains represent the fuel cost savings consumers will experience over the useful life of the more fuel efficient vehicle. We calculate these results for each vehicle category analyzed. Surplus losses without fuel savings and total social costs/gains with fuel savings are presented in the following analysis.

9.4 Potential Product Attribute Changes

It is anticipated that the air emission standards for recreational vehicles will be met by utilizing newer, cleaner, and quieter engine technologies. Anticipated engine technology changes are perhaps most significant for the snowmobile industry. While the ATV and off-highway motorcycle industries have utilized 4-stroke engine technology extensively absent regulation, the snowmobile manufacturers have been slow to introduce this technology. Current models of ATVs are comprised by approximately 80 percent 4-stroke technologies, while the 4-stroke technology represents approximately 55 percent of off-highway motorcycles sales. In contrast, only nine 4-stroke snowmobile models are currently available in the marketplace, and the sales of these vehicles are estimated to account for a small percentage of annual total snowmobile sales. An issue has been raised as to whether the technology changes envisioned to meet the emission standards for recreational vehicles will create attribute changes in vehicles sold. Since the engine technology changes contemplated may be the most significant for snowmobiles, this issue is addressed specifically for this industry in the economic analysis. The relevant question to be addressed from an economic perspective is will snowmobiles post-regulation be perceived from the consumer's perspective as the same product as snowmobiles pre-regulation? Further, will any product attribute changes be adversely or positively viewed by consumers impacting snowmobile demand post-regulation?

Particular product attribute changes alleged to negatively impact snowmobile sales relate specifically to potential performance changes. Modifications to engines may impact the versatility, reliability, or compactness of snowmobiles. Assertions have arisen that consumers of snowmobiles demand high power-to-weight ratio machines and that the new engine technologies contemplated will impair this product attribute. The issue of whether the increased costs per engine will make entry level machines too costly for the entry level or marginal consumer have also been claimed.

Potential product attribute changes are relevant to evaluate the economic impacts of the rule. The economic analysis conducted for this rule postulates that the post-regulation demand for snowmobiles will be identical to the pre-regulation demand for snowmobiles. Consumers will simply respond to the increased cost of an engine and based upon this increased price will likely reduce the quantity of snowmobiles purchased (a movement along a demand curve as opposed to a shift). If however, consumers view these product attribute changes as significant, demand for the product may increase or decrease (demand shift inward or outward). For positive attributes demand may increase (demand shifts outward). Under this scenario, consumers will be willing to pay a higher price for the product because they value the enhanced or new product attribute. If consumers view the product changes negatively, the opposite reaction occurs and demand decreases (demand shifts inward). With decreased demand, consumers will pay a lesser price for the product due to their perceptions that the attribute change negatively affects the value of the product to them. If consumers view the attribute changes positively, the economic analysis overstates market impacts. However, if consumers view the attribute changes negatively, the economic analysis understates the market impacts of the rule. Thus it is important to account for potential product attribute changes in order to provide a reasonable estimation of the potential economic consequences of the rule.

The technology changes envisioned for snowmobiles will enhance the fuel efficiency of snowmobiles. The issue of consumer potential reactions to fuel efficiency gains, a possible positive product attribute change are discussed in Section 9.3. The 4-stroke and direct fuel injection (dfi) technologies also offer the positive attribute of “cleaner and quieter” vehicles. The health and environmental benefits analysis of the rule presented in Chapter 10 assesses the public’s willingness to pay for the human health and environmental benefits of these “cleaner and quieter” technologies. A separate, but somewhat related question is whether snowmobile consumers are willing to pay for these product attributes. It is the latter issue that is relevant for the study of attributes.

The National Park Service (NPS) banned the use of snowmobiles for Yellowstone and Grand Teton National Parks in January 2001. This ban on snowmobile use was based upon the belief that snowmobile usage “adversely affects air quality, wildlife, natural soundscapes, and the enjoyment of other visitors” to the parks.[3] Both the “clean and quiet” aspects of snowmobile attributes are reflected in the NPS ruling. The NPS service is now reviewing their ban and may reverse the ban and allow snowmobiles in the parks with restrictions. It is possible that these actions may impact consumer’s demand for “clean and quiet” engine technologies versus the older technologies. The outcome of the NPS activities on sales of snowmobiles and the mix of technologies consumers will demand is an uncertainty in the economic analysis conducted for this market and the evaluation of consumer’s valuation of product attributes.

The EPA has conducted a product attribute analysis for snowmobiles to address the issue of potential product attribute changes that may occur as a result of this regulation. Specifically, the EPA has looked at the products currently available in the marketplace and those attributes associated with the machines sold. Special emphasis is made to address those attributes that may change with the regulation.

9.4.1 Technology Changes for Snowmobiles

The technology changes anticipated for the snowmobile industry to meet the standards are addressed in Chapter 4 of this report. These standards do not dictate the use of a particular technology, but the engineering analysis evaluates currently available technologies that will meet the emission standards. With the Phase 2 standards for snowmobiles, 50 percent reductions in HC and CO emissions are mandated. While snowmobile manufacturers may meet these standards in a variety of ways, the EPA estimates 20 percent of the market will use 4-stroke technology, 50 percent direct fuel injection technology, 20 percent modified 2-stroke engines with pulse air, and 10 percent will use unmodified 2-stroke technologies. This technology mix is used to calculate the engineering costs of the rule. It is relevant to note that the standards allow for fleet emissions averaging. Thus particular manufacturers may choose the vehicles most suited to the new technologies to meet the standards. Technologies chosen to meet the standards are also the choice of the manufacturer. This means a manufacturer fearing the loss of consumers for entry level machines may opt not to convert those machines to the newer technologies.

Currently all four manufacturers of snowmobiles produce machines with the 4-stroke technology. In its 2003 product line, Yamaha has introduced a new 4-stroke high performance model.[4] This machine represents a total redesign for the company's highest performance machine. The Yamaha RX-1 is reported to have a horsepower rating of 145 making it one of the most powerful snowmobiles available in the market. The redesigned machine offers a high power-to-weight ratio that compares favorably to high performance 2 stroke competitor models. Yamaha has redesigned the chassis and suspension of its 4-stroke model to achieve the goal of high power to weight performance. Not only is the cleaner and quieter technology compatible with the high performance and maneuverability, this combination has already been introduced into the market with positive reviews.[5] For several snowmobile manufacturers, the 4-stroke technology is offered in more moderately priced, low to middle power range vehicles. For example, the two 4-stroke machines offered for sale by Arctic Cat have estimated horsepower of approximately 53. Thus, different manufacturers within the market place are introducing the newer technologies using dissimilar marketing strategies. A relevant issue from the economic impact perspective is whether snowmobile manufacturers currently in the market are in the same competitive position to introduce these new technologies. This issue is discussed in Section 9.8 of this report.

9.4.2 Statistical Analysis of Snowmobile Product Attributes

In order to address the issue of potential product attribute changes, a statistical analysis of product attributes for all snowmobiles in the 2003 model line is conducted. One technique frequently used to value product attributes is the hedonic model. This model is used extensively in the economic literature to measure consumer's willingness to pay for particular product attributes. The hedonic model assumes that there is a continuous function relating the market price of a good to its constituent attributes. The assumption is made that snowmobile consumers select a snowmobile based upon the marginal value they place on individual snowmobile attributes and the price of those attributes. By analyzing the prices of products currently available in the market, one may gain knowledge of those product attributes consumers value and perhaps gain some insight as to consumer's view of potential changes in those product attributes.

An important limitation of the analysis must be addressed. The hedonic model estimated reflects a market equilibrium relationship between price and product attributes for a single model year. The equilibrium exists because producers of snowmobiles equate the marginal cost of producing attributes to consumer's willingness to pay for available attributes. The hedonic model adjusts until the marginal cost equals the marginal willingness to pay and equilibrium is achieved. However, the regulations considered will impose a non-marginal change in the product characteristics; therefore one cannot equate the value to consumers directly from this model. Thus the statistical hedonic models estimated cannot be used predictively to evaluate potential market impacts of the regulation (potential shifts in market demand). Additional modeling is required to conduct this type of estimation. Rather, these statistical models provide insight into implicit attribute prices for current product attributes. As stated previously in 9.3, the market model used to assess market impacts for these regulations assumes that no shifts in demand will occur as a result of this regulation.

9.4.2.1 Relevant Product Attributes

An assumption is made that different snowmobiles model prices may be represented by accounting for individual product attributes. Thus, the price of a particular snowmobile model is assumed to be a function of these characteristics. The goal of the hedonic analysis is to determine those product attributes that account for the product price and to analyze those attributes likely to change with regulation.

In order to complete the snowmobile hedonic analysis, an accounting of current product characteristics and those likely to change with regulation is conducted. Product specifications may be separated into the following categories: engine, chassis, dimensions, features, and other attributes. Engine specifications likely to contribute positively to the price of a snowmobile include engine type, engine size (displacement cc), number of cylinders, cooling system, ignition, transmission, breaking system and carburetion. Chassis characteristics involve elements that affect the maneuverability and handling of the vehicle such as suspension and shocks. The length, width, height, weight and fuel capacity are examples of dimension attributes of snowmobiles. Snowmobiles features include a variety of items such as electric start, reverse, seating capacity, color and other enhancements to the vehicles. Finally the brand of snowmobile may have some influence upon product price. Each of the previously listed product attributes potentially influence the price of a vehicle. Those directly measured in the study are chosen based upon the availability of data and the ability to measure these attributes. The characteristics hypothesized to influence price for purpose of this study include engine type, engine displacement cc, the cooling system type, carburetion type, vehicle dimensions (length, width), fuel capacity (impacts the range a vehicle may travel on a tank of gas), seating, electric start, reverse, and color. Color is essentially eliminated as an issue relevant for study by using Manufacturers Suggested Retail Price (MSRP) values for the basic paint vehicles. Other product attributes not evaluated in the study are either unavailable from publicly available sources (snowmobile manufacturers websites), available for a subset of the companies, or difficult to evaluate given the information provided. For example, transmission changes may occur when using new technologies, but transmission types are difficult to measure in a quantitative or qualitative manner as all snowmobiles have automatic transmissions.

Of these attributes, engine type, engine displacement, carburetion, cooling system, and vehicle dimensions (length, width, and fuel tank size) may change with the regulation. Each of these attributes potentially impact the performance of the vehicle. Engine displacement is a measure of the power of the vehicle. In general for 2-stroke engines the greater the engine size the greater the power. In contrast, the relationship between engine displacement and power in the 4-stroke engine is less direct, and this phenomenon may introduce measurement error when looking at a data set that combines 2-stroke and 4-stroke vehicles. While horsepower (hp) may be a better measure of this attribute, hp data are not readily available for all vehicle models. Ideally weight would be the better measure than vehicle length and width to test power-to-weight influence upon price. However, weight data are available for only a subset of snowmobiles offered for sales. Thus width and length proxy for the weight of the vehicle. Consumer's taste and preferences for engine power appear to be changing over time with the demand for greater power machines increasing. According to PSR data, the average engine displacement sized snowmobile produced rose significantly between 1995 and 2000.[6]

The issue of fuel efficiency and consumers willingness to pay for increased fuel efficiency is addressed in part with the fuel tank size variable. Gasoline mileage (miles per gallon) and range (length in hours of a ride with a single tank of gas) information are not available for any snowmobile models on any of the company websites. The absence of any information concerning fuel efficiency is somewhat surprising and may perhaps indicate that snowmobile sellers do not perceive that consumers of snowmobiles have great interest in the relative fuel efficiency of different products. Thus informational problems exist currently for consumers to be able to assess the fuel efficiency of products on the market. However, those products with 4-stroke and dfi technologies are reported to have fuel savings of up to 30% over comparable vehicles with older technologies.[7] Due to the absence of published fuel efficiency data, engine testing data provided by ISMA and from publications are used to construct a statistical relationship between mileage and engine size.[8] All data in the sample are based upon the 2-stroke engine technology. Based upon the sample engine test data, the statistical relationship estimated follows:

Hypothesized relationship: Gallons per hour = f (engine displacement cc)

Fitted Equation: Gallons per hour = -1.56615 + .00920 engine displacement cc

This equation is used to estimate gallons per mile for each of the vehicles in the data set. The gallons per hour are then converted to miles per gallon to estimate mileage for each vehicle type. This information is used along with fuel tank size to estimate the range of each vehicle. The descriptive statistics for data used in the model, parameter estimates, and relevant statistical model information are displayed on Table 9.4-1. The fitted model estimates gallons per hour for 2-stroke vehicles only. It is assumed that 4-stroke vehicles and those equipped with dfi have fuel efficiency gains over comparable 2-stroke vehicles of 25 percent. The mileage and range estimates constructed appear to systematically underestimate the mileage experienced by the typical snowmobile and the range for many of the vehicles appears to be understated suggesting measurement error in these estimates. While these data are used in the analysis, potential measurement errors in the data exist.

As indicated in the fitted equation, mileage is a function of engine size and as the engine size increases fuel consumption increases. The implications of this relationship are quite interesting. If consumers positively value power and power is inversely related to fuel efficiency, product prices may indicate consumers negatively value fuel efficiency. This is an inaccurate conclusion. We assume consumers are rational and value fuel efficiency. A more accurate description of this phenomenon is consumers value power and are willing to pay higher prices for larger engine sizes with greater power. Fuel efficiency declines within 2-stroke models with larger engines.

The prices consumers pay for the attributes of power (measured as engine size displacement) and fuel efficiency (mileage) are jointly determined. The modeling approach taken evaluates the implicit price of the attribute engine size. It is likely that consumers currently have a lower implicit price for engine displacement than would occur if this engine displacement also included greater fuel efficiency. Thus it is important to recognize these attributes are inextricably linked when consumers make purchase choices. The new technologies of dfi and 4-stroke engines do, however, represent the potential to gain fuel efficiencies for a given level of engine power, all other factors held constant.

Table 9.4-1
Statistical Model of Snowmobile Gas Mileage

Data Descriptive Statistics[9] Sample Size = 15 Variable description:	**Mean**	**Standard Deviation**
Engine Size (displacement cc)	540.9	173.2
Gallons per hour	3.41	1.73
Statistical Model Specification: Gallons per hours = f (engine displacement) Gallons per hour = $\beta_1 + \beta_2$ (engine displacement) + ϵ		
Model Results: Gallons per hour = -1.56615 + .00920 engine displacement cc		
Statistical Information Variable:	Parameter Estimate	Standard Errors
Intercept	-1.56615	0.60571*
Engine displacement	0.00920	0.00107**
F-Value	73.95	Pr > F < 0.0001
Adjusted R Square	0.839	

* Statistically significant at the 2% significance level.

** Statistically significant at the 1% significance level

9.4.2.2 Data for Hedonic Analysis

The websites of Polaris, Arctic Cat, Bombardier, and Yamaha include listings of the 2003 models available for sale. [10, 11, 12, 13] The specifications for each snowmobile model are listed on these websites and these data are used as the data set for the study. Data are presented for the one hundred and forty four models offered for sale in the 2003 product lines of these manufacturers. Children's snowmobiles are excluded from the study, because the technologies used in this application differ greatly from the typical snowmobile available for sale.

The price of a snowmobile is the dependent variable in the statistical estimation and price must be measured to complete the hedonic analysis. MSRP are used to measure the price of vehicles offered for sale. While the actual price paid for a snowmobile typically is a negotiated price between the buyer and seller, only MSRP are published and readily available for models currently offered for sale. Descriptive Statistics for snowmobile prices and product attributes are shown on Table 9.4-2.

Table 9.4-2
Snowmobile Price and Product Attribute Descriptive Statistics - All Vehicles [14]
(Sample Size = 144)

Product Attributes	Measurement	Mean Value	Standard Deviation
Engine Type	2-stroke versus 4-stroke	Dummy Variable 0 = 2-stroke 1 = 4-stroke (9 4-stroke)	N/A
Engine Size	cubic centimeters	642	144
Cooling System	air cooled or liquid cooled	Dummy Variable 0 = air cooled 1 = liquid cooled (114 liquid cooled)	N/A
Length	inches	116.6	6.7
Width	inches	46.6	1.9
Fuel Tank Size	gallons	11.3	1
Seating Capacity	1 or 2 person vehicle	Dummy Variable 0 = 2 person 1 = 1 person (106 1-person)	N/A
Electric Start	standard equipment or optional	Dummy Variable 0 = option 1 = standard (55 standard)	N/A
Reverse	standard equipment or optional	Dummy Variable 0 = optional 1 = standard (81 standard)	N/A
Electronic Fuel Injection (efi)	Included or not included	Dummy Variable 0 = no efi 1 = efi (27 efi)	N/A
Direct Fuel Injection (dfi)	Included or not included	Dummy Variable 0 = no dfi 1 = dfi (6 dfi)	N/A
Brand Name	Polaris, Arctic Cat, Bombardier, or Yamaha	Dummy Variables 1 = particular brand	N/A

Mileage	Miles per gallon	6.2	2.7
Range	Miles traveled on a tank of gas	69.3	26.3
Dependent Variable: Snowmobile price	Manufacturers suggested retail price	$7,291	$1,411

Since the 4-stroke engine represents a significant technical departure from the 2-stroke engines, alternative models are estimated for the 2-stroke and 4-stroke models exclusively. The descriptive statistics for those variables subject to quantitative estimates for the 4-stroke and 2-stroke models are shown on Tables 9.4-3 and 9.4-4, respectively. In general, qualitative variables measured by dummy variables are measured as depicted for all vehicles. Some features that are measured using dummy variables are not applicable for the 4-stroke technology. For example, all 4-stroke engines are liquid cooled and have electric start as standard features. Dfi technology is available exclusively on 2-stroke models. Horsepower data are available for all nine 4-stroke models.

Table 9.4-3
Snowmobile Price and Product Attribute Descriptive Statistics[15]
Four-Stroke Models Only (Sample Size =9)

Product Attributes	Measurement	Mean Value	Standard Deviation
Engine Size	cubic centimeters	872	150.7
HP	number	88.6	44
Length	inches	116.6	8.5
Width	inches	47.3	1.4
Fuel Tank Size	gallons	11.1	1.1
Brand Name	Polaris, Arctic Cat, Bombardier, or Yamaha	Dummy Variables 1 = particular brand	N/A
Mileage	Miles per gallon	4.9	1.3
Range	Miles traveled on a tank of gas	55.4	20.7
Dependent Variable: Snowmobile price	Manufacturers suggested retail price	$8,316	$687

Table 9.4-4. Snowmobile Price and Product Attribute Descriptive Statistics[16]
Two-Stroke Models Only (Sample Size = 135)

Product Attributes	Measurement	Mean Value	Standard Deviation
Engine Size	cubic centimeters	626.4	130.7
Length	inches	116.5	6.5
Width	inches	46.6	1.9
Fuel Tank Size	gallons	11.2	0.9
Brand Name	Polaris, Arctic Cat, Bombardier, or Yamaha	Dummy Variables 1 = particular brand	N/A
Mileage	Miles per gallon	6.3	2.8
Range	Miles traveled on a tank of gas	69.9	26.3
Dependent Variable: Snowmobile price	Manufacturers suggested retail price	$7,213	$1,423

9.4.2.3 Statistical Model Results

This section presents the results of statistical estimations including results of statistical tests. The statistical package, SAS 8.2 for Windows was used to generate all statistical results. Various model specifications were estimated including log-log, log-linear and linear models. Generally, the log-log model specification provided the best statistical fit. In this model, all variables are transformed to natural logs except the dummy variables. Numerous model variations were estimated. In nearly all model specifications, the variables electric start, electronic fuel injection, brand name, length, fuel tank size, and electric start are consistently not statistically significant. Since the range and mileage variables are a function of the engine size, these variables are highly correlated. For this reason, model runs were conducted with engine size, range or mileage exclusively. The 4-stroke parameter is correlated with engine size variable. When the model is specified using both of the parameters, the 4-stroke variable appears to have a negative coefficient and to be statistically significant. When the model is estimated with the 4-stroke variable and excludes engine size, the parameter estimates are not significantly different from zero. Thus the fitted model excludes 4-stroke technology from the estimation. It is possible that a dummy variable is not an adequate method of capturing the attributes associated with the technology. Given this results a hedonic models of 2-stroke and 4-stoke models only are estimated. The estimated hedonic function for the full model using engine size follows:

$$\log MSRP = 8.2419 + 0.5821 \log(\text{engine displacement cc}) + 0.8561 \log(\text{width}) + 0.2397\ \text{cooling} - 0.0685\ \text{seat} + 0.0495\ \text{reverse} + 0.1066\ \text{dfi}.$$

All parameter estimates are significant at a 1 percent significance level. Relevant statistical model results are shown on Table 9.4-5.

Table 9.4-5
Full Model Statistical Results Using Engine Displacement

Variable	Parameter Estimate	Standard Error*
Intercept	8.2419	0.6987
log (engine displacement cc)	0.5821	0.0362
log (width)	0.8561	0.1713
cool	0.2397	0.0223
seat	-0.0685	0.0159
reverse	0.0495	0.0143
dfi	0.1066	0.0343
F Value	157.28*	
Adjusted R-Square	0.8677	

* All parameter estimates are statistically significant at a 1% significance level.

The model is re-estimated using the same specifications and variables shown in Table 9.4-5, but replacing engine size with a mileage variable and in a subsequent run with the range variable. The models and parameter estimates remain statistically significant. The mileage variable and range variable have negative signs as previously postulated and are statistically significant in each of the runs.

Based upon the statistical results, one may conclude that the relative prices (as measured by MSRP) are higher for vehicles with larger engine sizes, greater width, liquid cooling systems, reverse, and dfi. Alternatively, one-seating capacity machines are priced generally lower than two-seat machines. In the alternative model specifications, the mileage and range variables have negative signs and are statistically significant. This result may be interpreted to mean that consumers value power even when greater power translates into less fuel efficiency.

The full data set is split into a 4-stroke data set and a 2-stroke data set to assess the model differences with these two technologies. The model estimation results for the 2-stroke technology are as follows:

$$\text{Log (MSRP)} = 7.5689 + 0.6461 \text{ log (engine displacement cc)} + 0.7847 \text{ log (width)} + 0.2260 \text{ cool} + 0.0626 \text{ reverse} - 0.0722 \text{ reverse} + 0.0906 \text{ dfi}$$

Statistical results are shown in Table 9.4-6. In general, the results of this run differ little from the full model. This is not surprising since 135 observations of the full data set are represented in the 2-stroke model specification. Thus the conclusions for the full model apply to the two-stroke technology.

Table 9.4-6
Two-Stroke Model Statistical Results Using Engine Displacement

Variable	Parameter Estimate	Standard Error*
Intercept	7.5689	0.6984
log (engine displacement cc)	0.6461	0.0386
log (width)	0.7847	0.1683
cool	0.226	0.0218
reverse	0.0626	0.0143
seat	-0.0722	0.0143
dfi	0.0906	0.0333
F Value	165.49*	
Adjusted R-Square	0.8805	

* All parameter estimates are statistically significant at a 1% significance level.

Only nine 4-stroke models are currently available for sale. Thus the sample size is quite small. In general, only engine size or horsepower are statistically significant. Horsepower provides a stronger statistical relationship to MSRP and the model results are shown below:

$$\text{log (MSRP)} = 8.3330 + 0.1577 \text{ log (hp)}$$

Model results are shown in Table 9.4-7.

Table 9.4-7
Four-Stroke Model Statistical Results Using Engine Horsepower

Variable	Parameter Estimate	Standard Error *
Intercept	8.333	0.1064
log (horsepower)	0.1577	0.0242
F Value Adjusted R-Square	42.53* 0.8941	

* All parameter estimates are statistically significant at a 1% significance level.

The model results tend to provide confirmation that higher powered (greater hp) four-stroke machines are higher priced that than lower powered 4-stroke machines.

In general, the statistical results from all model runs tend to indicate that higher MSRP exist in the current snowmobile market for power (larger engine size or hp), wider machines, liquid cooling, reverse, and dfi product attributes. One-seat machines, all other factors held constant, are lower priced than two-seat machines. The statistical results also indicate prices are higher for vehicles equipped with the dfi technology.

The statistical results indicate that fuel efficiency is inversely related with engine size. Since prices are relatively higher for more powerful machines, this translates to lower fuel efficiency. This phenomenon is related to the two-stroke technology. This does not likely reflect a negative view of fuel efficiency so much as a positive view of greater power. While consumers of 4-stroke models also are willing to pay higher prices for greater power, greater fuel efficiency is an intrinsic attribute of the 4-stroke technology. The model results are not satisfying with regard to the 4-stroke technology. This is likely due to the fact that the dummy variable does not adequately capture the attributes associated with the 4-stroke technology and may also be due to the relatively small number of models with this technology.

9.4.3 Anecdotal Pricing Information For Snowmobiles

The statistical analysis is unsuccessful at identifying product price differentials for the 4-stroke technology versus 2-stroke. For this reason, a model by model comparison is conducted of the 4-stroke snowmobile models that are similar except for engine type. The MSRP differential typically ranges from $500 to $600 for the 4-stroke model when compared to the 2-stroke comparable model.[17] The prices consumers actually pay for these comparison vehicles are ultimately dependent upon a negotiated price rather than MSRP.

9.4.4 Uncertainties and Limitations of the Attribute Study

The statistical uncertainties of the attribute study are presented in the discussions of the models estimated. In additional to the statistical uncertainties, other uncertainties exist. The outcome of NPS issues with snowmobile usage in national parks is an uncertainty that cannot be adequately addressed in the analysis. To the extent that NPS actions, spur demand for "cleaner and quieter" snowmobiles, demand for the new technologies may increase. However, the overall impact of a ban on snowmobile usage in the parks is a recognized uncertainty of the economic impact analysis conducted for this rule.

The hedonic model estimated reflects a market equilibrium relationship between price and attributes for a single model year. The equilibrium exists because producers of snowmobiles equate the marginal cost of producing attributes to consumer's willingness to pay for available attributes. The hedonic model adjusts until the marginal cost equals the marginal willingness to pay and equilibrium is achieved. However, the regulations considered will impose a non-marginal change in the product characteristics; therefore one cannot equate the value to consumers directly from this model. Additional modeling is required to conduct this type of estimation.

9.4.5 Conclusions

Two questions are posed at the beginning of this analysis regarding potential product attribute changes. Those questions are: will snowmobiles post-regulation be perceived from the consumer's perspective as the same product as snowmobiles pre-regulation and will product attribute changes be adversely or positively viewed by consumers impacting snowmobile demand post-regulation? The answer to the first question is that the technology changes envisioned by the rule do alter the attributes of snowmobiles such that the typical consumers of snowmobiles post-regulation will view these products as different from the pre-regulation snowmobile. Two qualifiers to this conclusion exists. The first is that these technologies are already available in the market place. The regulation will simply encourage the proliferation of these new technologies throughout the snowmobile market. The second is a mix of technologies will exist that include older technologies. Thus consumers of the older technology machines will not likely perceive product changes post regulation.

With regard to the second question, consumer demand may change as a result of these altered product attributes. However, quantification of any demand changes is not possible with the data evaluated. The negative aspects of product changes alleged by some involve potential degradation of the power-to-weight ratio for high performance machines. Yamaha's introduction of its new high performance 4-stroke machine is evidence that the "clean and quiet" technologies can coexist with high power-to-weight ratios. Thus consumers will be able to obtain "clean and quiet" high powered snowmobiles. The question then becomes are consumers willing to pay higher prices for the new attributes of cleaner, quieter, greater fuel efficiency, and other performance attributes of snowmobiles equipped with dfi or 4-stroke engines. The statistical analysis provides evidence that MSRP is higher for vehicles equipped with dfi, all other factors held constant. A comparison of the suggested MSRP of comparable 4-stroke and 2-stroke vehicles reflects higher prices for the 4-stroke engine vehicles currently offered in the market of approximately $500 to $600. Thus snowmobile manufacturer's recommend higher prices for the newer technologies. This recommendation reflects the belief that certain consumers will value the bundle of product attributes of the new cleaner quieter machines and be willing to pay a premium for these attributes. The actual price differences paid for new versus old technology vehicles is determined by those prices negotiated in the market. Further, the increased price may reflect an increased cost of production and not necessarily translate into additional profits for the manufacturer.

With regard to the issue of whether entry level consumers will leave the market, fleet emissions averaging will allow producers to use older less costly technologies on entry level machines to avoid sales losses for this segment of the market.

9.5 Methodology

For the economic impact analysis of the effects of the emissions control program, we rely upon a national-level partial equilibrium market model. Inputs to this model include baseline market price, market output (domestic and imported quantities), and estimates of price elasticity of supply and demand. Price elasticities measure the responsiveness of quantity demanded and supplied to changes in price. This section describes the conceptual model used to generate the economic impacts and it provides the methodology and data inputs used to develop estimates of supply and demand price elasticities for each vehicle category.

9.5.1 Conceptual Model

The regulatory compliance costs provide an exogenous shock to the model with the per unit total compliance costs (*c*) resulting in a shift of the domestic supply curve (S_0 to S_1 in Figure 9.2-2 above). This shift, expressed as the cost increase per vehicle, is based on the cost information presented in Chapter 5 (generally, the regulatory cost per engine is taken to equal the cost per vehicle). The model equations that respond to this exogenous shock are described below.

The change in domestic supply (dq^D) due to the imposition of the regulation will depend upon the typical supply response to a price increase and the change in the "net" price of a given vehicle (i.e., $dP - c$) so that

$$dq^D = \xi^D \left[\frac{q^D}{P}\right](dP - c) \qquad \textbf{(Eq. 9-1)}$$

where ξ^D is the domestic supply elasticity. Supply elasticities have been estimated for each of the vehicle categories affected by the emissions standards and a description of the estimation procedure used is provided below.

International trade is included through the specification of an equation to characterize imports to the U.S. Thus, the change in imports from these foreign countries is included through the following equation:

$$dq^I = \xi^I \left[\frac{q^I}{P} \right] (dP - c) \qquad \textbf{(Eq. 9-2)}$$

where ξ^I is the import supply elasticity. Data to estimate import supply elasticities for the various vehicle categories were not available. For the economic impact analysis, the value of the import supply elasticity is assumed to equal the value of the domestic supply elasticity.

Next, the change in market supply must equal the change in the quantity of individual suppliers both domestic and foreign, i.e.,

$$dQ = dq^D + dq^I \qquad \textbf{(Eq. 9-3)}$$

where dq^D is the change in domestic supply and dq^I is the change in imports.

Lastly, the market demand condition must hold, i.e.,

$$dQ = \eta \left[\frac{Q}{P} \right] dP \qquad \textbf{(Eq. 9-4)}$$

where η is the market demand elasticity. The economic model relies upon demand elasticities that have been estimated or found in the economics literature for the various vehicle categories. Estimation procedures for demand elasticity are discussed below.

Equations 9-1 through 9-4 form four linear equations with four unknowns (dq^D, dq^I, dQ, and dP) that can be solved using linear algebra, i.e.,

$$\mathbf{b} = \mathbf{A}^{-1}\mathbf{c}'$$

where **b** is the vector containing the four unknowns (dq^D, dq^I, dQ, and dP), $\mathbf{A}^{-1}$ is the inverse of A, a 4x4 matrix, and **c** is the vector (c, c, 0, 0). Using this model, we develop our national-level economic impacts resulting from the rule. The full system of equations (**Ab = c**) is as follows:

$$\begin{bmatrix} -\left(\frac{1}{\varepsilon^d}\right)\left(\frac{P}{q^d}\right) & 0 & 0 & 1 \\ 0 & -\left(\frac{1}{\varepsilon^d}\right)\left(\frac{P}{q^i}\right) & 0 & 1 \\ -1 & -1 & 1 & 0 \\ 0 & 0 & -1 & \eta\frac{Q}{P} \end{bmatrix} \begin{bmatrix} dq^d \\ dq^i \\ dQ \\ dP \end{bmatrix} = \begin{bmatrix} c \\ c \\ 0 \\ 0 \end{bmatrix} \qquad \textbf{(Eq. 9-5)}$$

9.5.2 Price Elasticity Estimation

As discussed above, demand and supply elasticities are crucial components of the partial equilibrium model used to quantify the economic impacts of the emission standards. The price elasticity of demand is a measure of the sensitivity of buyers of a product to a change in price of the product. The price elasticity of demand represents the percentage change in the quantity demanded resulting from each 1 percent change in the price of the product. The price elasticity of supply is a measure of the responsiveness of producers to changes in the price of a product. The price elasticity of supply indicates the percentage change in the quantity supplied of a product resulting from each 1 percent change in the price of the product.

This section presents the analytical approach employed to estimate the demand and supply price elasticities used in the partial equilibrium analysis for each vehicle category. As discussed below, demand and supply elasticity estimates used in the market model are either estimated, assumed, or retrieved from previous studies that have carried out these estimations. In the case of recreational diesel marine vessels, a demand elasticity measure was available from a previous study, but the supply elasticity was estimated. For forklifts, both supply and demand elasticities were estimated. Because of data limitations, EPA's estimates of demand elasticity for the forklift model are not considered robust. Two estimates were generated; one was not significant while the other was significant but not of reasonable size. The economic impact analysis therefore relies upon an assumed price elasticity of demand for forklifts based on the results generated for this vehicle category. A sensitivity analysis is included in an appendix to show the economic impacts of the rule on the forklift market when the large estimate of demand elasticity is used. For the snowmobile, ATV, and OHM markets, attempts were made at econometric estimation of the price elasticity of demand. These attempts were unsuccessful as was a search to find these data in the literature. In lieu of estimates specific to the snowmobile, ATV and the OHM markets, an estimate of the price elasticity of demand for recreational boats obtained from a study are used to estimated market impacts. This value is assumed to be a reasonable estimate of the price elasticity of demand for the snowmobile, ATV and OHM markets. The uncertainties involved in this estimate are acknowledged. A sensitivity analysis is included in the Appendix to Chapter 9 to recognize the uncertainties associated with this estimate. The price elasticity of supply is estimated for the snowmobile and OHM markets. Attempts to estimate this value for the ATV market were unsuccessful. The price elasticity of supply estimate generated for the OHM market is assumed to be a reasonable estimate of this value for the ATV market. Sensitivity analyses are presented in the appendix to this chapter to evaluate the uncertainties involved in these estimates. A summary of the price elasticity of demand and supply used in the study for each vehicle type are summarized in Table 9-5.0 shown below.

Table 9-5.0 Summary of Price Elasticity of Demand and Supply Used in the Market Analyses

Market	Price Elasticity of Demand	Price Elasticity of Supply
Inboard Cruisers	-1.41	1.62
Forklifts	-1.52	0.72
Snowmobiles	-2.03	2.12
ATVs	-2.03	1.04
Off-highway motorcycles	-2.03	0.92

[1] Raboy, David. G. 1987. *Results of an Economic Analysis of Proposed Excise Taxes on Boats*. Washington, D.C: Patton, Boggs, and Blow. Prepared for the National Marine Manufacturing Association. Docket A-2000-01, Document IV-A-129.
[2] Assumed value.
[3] Econometrically estimated.
[4] Assumed value based upon the price elasticity of demand estimate for recreational boats in the Raboy study listed above.
[5] Assumed value based upon the price elasticity of supply estimate for off-highway motorcycles.

9.5.2.1 Price Elasticity Estimation for Marine

Demand Elasticity

The economic model developed for the CI recreational marine vessel market concentrates solely on the inboard cruiser market. This is the segment of the recreational marine vessel market which relies upon diesel engines more than any other. Fortunately, a previously estimated price elasticity of demand for the inboard cruiser market is available[18]. For this reason, demand elasticity was not estimated. The previously estimated value that is used in the economic model is -1.44.

Supply Elasticity

Published sources of the price elasticity of inboard marine cruisers were not readily available. Therefore, an econometric analysis of the price elasticity of supply for boat manufacturing was conducted, assuming that this estimate is representative of the supply elasticity for the inboard cruiser market. The approach used to estimate the supply elasticity makes use of the production function. The methodology of deriving a supply elasticity from an estimated production function will be briefly discussed with the industry production function defined as follows:

$$Q^S = f(L, K, M, t) \qquad \textbf{(Eq. 9-6)}$$

where:

Q^S	=	output or production
L	=	the labor input, or number of labor hours,
K	=	real capital stock,
M	=	the material inputs, and
t	=	a time variable to reflect technology changes.

In a competitive market, market forces constrain firms to produce at the cost minimizing output level. Cost minimization allows for the duality mapping of a firm's technology (summarized by the firm's production function) to the firm's economic behavior (summarized by the firm's cost function). The total cost function for a boat producer is as follows:

$$TC = h(C, K, t, Q^S) \qquad \textbf{(Eq. 9-7)}$$

where:

TC	=	the total cost of production, and
C	=	the cost of production (including cost of materials and labor).

All other variables have been previously defined.

This methodology assumes that capital stock is fixed, or a sunk cost of production. The assumption of a fixed capital stock may be viewed as a short-run modeling assumption. This assumption is consistent with the objective of modeling the adjustment of supply to price changes after implementation of controls. Firms will make economic decisions that consider those costs of production that are discretionary or avoidable. These avoidable costs include production costs, such as the costs associated with labor and materials. In contrast, costs associated with existing capital are not avoidable or discretionary. Differentiating the total cost function with respect to Q^S derives the following marginal cost function:

$$MC = h'(C, K, t, Q^S) \qquad \textbf{(Eq. 9-8)}$$

where *MC* is the marginal cost of production and all other variables have been previously defined.

Profit maximizing competitive firms will choose to produce the quantity of output that equates market price, *P*, to the marginal cost of production. Setting the price equal to the preceding marginal cost function and solving for Q^S yields the following implied supply function:

$$Q^S = (P, P_L, P_M, K, t) \qquad \textbf{(Eq. 9-9)}$$

where:

P	=	the price of recreational marine vessels,
P_L	=	the price of labor, and
P_M	=	the price of materials input.

All other variables have been previously defined.

An explicit functional form of the production function may be assumed to facilitate estimation of the model. For this analysis, the Cobb-Douglas, or multiplicative form, of the production function is postulated. The Cobb-Douglas production function has the convenient property of yielding constant elasticity measures. The functional form of the production function becomes:

$$Q_t = AK_t^{\alpha_K} t^{\lambda} L_t^{\alpha_L} M_t^{\alpha_M} \qquad \textbf{(Eq. 9-10)}$$

where:

Q_t	=	output or production in year t,
K_t	=	the real capital stock in year t,
L_t	=	the quantity of labor hours used in year t,
M_t	=	the material inputs in year t, and
A, α_K, α_L, α_M, λ	=	parameters to be estimated by the model.

This equation can be written in linear form by taking the natural logarithms of both sides of the equation. Linear regression techniques may then be applied. Using the approach described, the implied supply function may be derived as:

$$\ln Q = \beta_0 + \gamma \ln P + \beta_1 \ln K + \beta_2 \ln P_L + \beta_3 \ln P_M + \beta_4 \ln t \qquad \textbf{(Eq. 9-11)}$$

where:

P_L	=	the factor price of the labor input,
P_M	=	the factor price of the material input, and
K	=	fixed real capital.

The β_i and γ coefficients are functions of the α_i, the coefficients of the production function. The supply elasticity, γ, is equal to the following:

$$\gamma = \frac{\alpha_L + \alpha_M}{1 - \alpha_L - \alpha_M} \qquad \textbf{(Eq. 9-12)}$$

It is necessary to place some restrictions on the estimated coefficients of the production function in order to have well-defined supply function coefficients. The sum of the coefficients for labor and materials should be less than one. Coefficient values for α_L and α_M that equal to one result in a price elasticity of supply that is undefined, and values greater than one result in negative supply elasticity measures. For these reasons, the production function is estimated with the restriction that the sum of the coefficients for the inputs equal one. This is analogous to assuming that the boat manufacturing industry exhibits constant returns to scale, or is a long-run constant cost industry. This assumption seems reasonable on an *a priori* basis and is not inconsistent with the data.

The estimated model reflects the production function for boats, using annual time series data for the years from 1958 through 1999. The following model was estimated econometrically, using real values of capital stock, production wages, and material inputs:

$$\ln Q_t = \ln A + \alpha_K \ln K_t + \lambda \ln t + \alpha_L \ln L_t + \alpha_M \ln M_t \qquad \textbf{(Eq. 9-13)}$$

where each of the variables and coefficients have been previously defined.

The data inputs used to estimate the supply elasticity are enumerated in Table 9.5-1. This table contains a list of the variables included in the model and the units of measure. The data for the price elasticity of supply estimation model includes: the value of domestic shipments in millions of dollars; the price index for the value of domestic shipments (the value of domestic shipments deflated by the price index represents the quantity variable which is the dependent variable in the analysis); a technology time variable; production wages in millions of dollars; the implicit GDP deflator (used to deflate production wages), the material inputs in millions of dollars; the price index for value of materials; investment in millions of dollars; the price index for investment; and real net capital stock in millions of dollars.

Table 9.5-1
Data Inputs for the Estimation of
Supply Elasticity for the Boat Building Industry[19,2021,22,23,24]

Variable	Unit of Measure
1. Value of Shipments for the Boat Building Industry (SIC 3732)	millions of $
2. Price Index of Shipments for the Boat Building Industry (SIC 3732)	index
3. Time trend	-
4. Production Worker Wages	millions of $
5. Implicit GDP Deflator	index
6. Cost of Material Inputs	millions of $
7. Price Index of Material Inputs	index
8. Investment	millions of $
9. Price Index of Investment	index
10. Real Capital Stock	millions of 1987$

Data to estimate the production function exclusively for inboard cruisers were largely unavailable; therefore, data for SIC code 3732 (Boat Building) is utilized for each of the variables previously enumerated with the exception of the time variable. All data for the supply elasticity estimation were retrieved from the National Bureau of Economic Research-Center for Economic Studies (NBER-CES) Productivity Database and the U.S. Census Bureau's Annual Survey of Manufactures (ASM), with the exception of the technology time trend, the implicit GDP deflator, the price index for investment for SIC 3732 for the years 1997 through 1999, the price indices of shipments and material inputs for SIC 3732 for the years 1998 and 1999, and real capital stock for the years 1998 and 1999 (these data for real capital stock were not available). These variables (except the time trend and real capital stock for 1998 and 1999), were retrieved from the Bureau of Economic Analysis (BEA).

More specifically, the price index of shipments for 1998 and 1999 was retrieved from the BEA's Shipments of Manufacturing Industries. Note that since a price index of material inputs for SIC 3732 was not available beyond 1997, we relied upon a general price index for intermediate materials from BEA's Survey of Current Business. A price index for investment for SIC 3732 was also not available beyond 1996, so a general price index for capital equipment was used for the years 1997 - 1999 from the same source. Last, real capital stock for the years 1998 and 1999 was calculated using the following formula:

$$\text{real cap stock}_i = \text{real cap stock}_{i-1} + \text{real investment}_i - \text{depreciation rate*real cap stock}_{i-1} \qquad \textbf{(Eq. 9-14)}$$

where i = 1998, 1999. The depreciation rate for capital for SIC 3732 was taken as the average depreciation rate over the last 10 years for which investment and capital stock data were available (1987 - 1996).

The capital stock variable was the most difficult variable to quantify for use in the econometric model. Ideally, this variable should represent the economic value of the capital stock actually used by each facility to produce boats for each year of the study. The most reasonable data for this variable would be the number of machine hours actually used to produce boats each year. These data are unavailable. In lieu of machine hours data, the dollar value of net capital stock in constant 1987 prices, or real net capital stock, is used as a proxy for this variable. However, these data are imperfect because they represent accounting valuations of capital stock rather than economic valuations. This aberration is not easily remedied, but is generally considered unavoidable in most studies of this kind.

SAS Release 8.2 for Windows was used to develop econometric estimates of the price elasticity of supply for the boat manufacturing industry. A restricted least squares estimator was used to estimate the coefficients of the production function model. A log-linear specification was estimated with the sum of the α_i restricted to unity. This procedure is consistent with the assumption of constant returns to scale. The model was further adjusted to correct for first-order serial correlation using the Yule-Walker estimation method. The results of the estimated model are presented in Table 9.5-2 with p-values listed in parentheses below each coefficient estimate.

Table 9.5-2
Estimated Supply Model Coefficients for the Boat Building Industry

Variables	Estimated Coefficients
ln(Time) *(t)*	0.3445* (<.0001)
ln(Real Capital Stock) (K_t)	0.3888* (<.0001)
ln(Real Production Wages) (L_t)	0.7604* (<.0001)
ln(Real Material Inputs) (M_t)	-0.1492* (<.0001)

* statistically significant

The coefficients for real capital and real production wages have the anticipated signs and are significant at a high level of confidence. The real material inputs coefficient does not have the anticipated sign but does test significantly different from zero. Using the estimated coefficients and the formula for supply elasticity shown above, the price elasticity of supply for boat manufacturing is derived to be 1.57. The calculation of statistical significance for this elasticity measure is not a straightforward calculation since the estimated function is non-linear. No attempt has been made to assess the statistical significance of the estimated elasticity. The corrections for serial correlation and the restricted model results yield inaccurate standard measures of goodness of fit (R^2). However, the model that is unrestricted and unadjusted for serial correlation has an R^2 of 0.99.

The estimated price elasticity of supply for the boat manufacturing industry reflects that the industry in the United States will increase production of boats by 1.57 percent for every 1.0 percent increase in the price of this product. The preceding methodology does not directly estimate the supply elasticity of inboard cruisers due to a lack of necessary data. The assumption implicit in the use of this estimate of price elasticity of supply is that the supply elasticity of inboard cruisers will not differ significantly from the price elasticity of supply for all products classified under SIC code 3732.

9.5.2.2 Price Elasticity Estimation for Forklifts

Demand Elasticity

Forklifts are used as intermediate products to produce final goods. The demand for large SI engine forklifts is therefore derived from the demand for these final products. Information is provided in Section 2.2 concerning the end uses of forklifts. According to this information, forklifts are used primarily as an input in the manufacturing and wholesale trade sectors. One primary use for forklifts is to lift and transport materials and merchandise in warehouse or retail trade settings. Forklifts are therefore used in the production of a wide variety of goods manufactured by these sectors of the economy.

The assumption was made that firms using forklifts as inputs into their productive processes seek to maximize profits. The profit function for these firms may be written as follows:

$$\underset{Q,I}{MAX}\ \pi = P_{FP} \times f(Q, I) - (P \times Q) - (P_{OI} \times I) \qquad \textbf{(Eq. 9-15)}$$

where:

π	=	profit,
P_{FP}	=	the price of the final product or end-use product,
$f(Q, I)$	=	the production function of the firm producing the final product,
P	=	the price of the forklifts,
Q	=	the quantity input use of forklifts
P_{OI}	=	a vector of prices of other inputs used to produce the final product, and
I	=	a vector of other inputs used to produce the final product.

The solution to the profit function maximization results in a system of derived demand equations for forklifts. The derived demand equations are of the following form:

$$Q \bullet g(P, P_{FP}, P_{OI}) \qquad \textbf{(Eq. 9-16)}$$

A multiplicative functional form of the derived demand equations are assumed because of the useful properties associated with this functional form. The functional form of the derived demand function is expressed in the following formula:

$$Q = AP^{\beta} P_{FP}^{\beta_{FP}} \qquad \textbf{(Eq. 9-17)}$$

where:

A	=	a constant
β	=	the price elasticity of demand for forklifts, and
β_{FP}	=	the final product price elasticity with respect to the use of forklifts.

All other variables have been previously defined and β, β_{FP}, and A are parameters to be estimated by the model. In the above equation, β represents the own-price elasticity of demand. The price of other inputs (represented by P_{OI}) has been omitted from the estimated model, because data relevant to these inputs were unavailable. The implication of this omission is that the use of forklifts in production is fixed by technology.

The market price and quantity sold of forklifts are simultaneously determined by the demand and supply equations. For this reason, it is advantageous to apply a systems estimator to obtain unbiased and consistent estimates of the coefficients for the demand equations.[25] Two-stage least squares (2SLS) is the estimation procedure used in this analysis to estimate the demand equation for forklifts. Two-stage least squares uses the information available from the specification of an equation system to obtain a unique estimate for each structural parameter. The first stage of the 2SLS procedure involves regressing the observed price of forklifts against the supply and demand "shifter" variables that are exogenous to the system. These are referred to as instruments. This first stage produces fitted (or predicted) values for the forklift price variable that are, by definition, uncorrelated with the error term by construction and thus do not incur endogeneity bias. These fitted values for price are then used in the second stage equation (see Eq. 9-17). By converting the above equation to natural logarithms, the coefficient on the forklift price variable (β) yields an estimate of constant elasticity of supply.

The exogenous supply-side variables used to estimate the demand function include: the real capital stock variable for SIC code 3537 (the industry that manufactures forklifts), a technology time trend (t), and the price indices for the cost of labor and the cost of materials for SIC code 3537. A price index for the cost of labor was generated by dividing real production worker wages (derived by dividing nominal production worker wages by the implicit GDP deflator) by production worker hours. The demand-side variables include: real GDP and the price indices of manufacturing and wholesale trade. Generally, the price of final products are used as demand-side variables, but because forklifts are used as an input to the production of a wide variety of goods, we rely upon price indices of the manufacturing and wholesale trade sectors.

Data relevant to the econometric modeling of the price elasticity of demand for forklifts are listed in Table 9.5-3. Consistent time series data for the period 1970 through 1999 were obtained. The annual domestic quantity of forklift shipments was retrieved from the Industrial Truck Association Membership Handbook. Price data for forklifts over this time period were not available, so the price index of shipments for SIC code 3537 was retrieved from both the NBER-CES Productivity Database and BEA's Shipments of Manufacturing Industries instead. The following variables were also retrieved from the NBER-CES Productivity Database and the Census Bureau's ASM: production worker wages, production worker hours, real capital stock (except for the years 1998 and 1999), investment, the price index of investment (except for the years 1997 through 1999), and the price indices of shipments and material inputs (except for the years 1998 and 1999).

Other variables, including the price indices for the manufacturing and wholesale trade industries, the implicit GDP deflator, real GDP, the price index of investment for SIC code 3537 for the years 1997 to 1999, and the price indices of shipments and material inputs for the years 1998 and 1999 were retrieved from the Bureau of Economic Analysis. Note that since a price index of material inputs for SIC 3537 was not available beyond 1997, we relied upon a general price index for intermediate materials from BEA's Survey of Current Business. A price index for investment for SIC 3537 was also not available beyond 1996, so a general price index for capital equipment was used for the years 1997 - 1999 from the same source. Real capital stock for the years 1998 and 1999 was derived for SIC 3537 (see Equation 9-13 for the equation used to calculate real capital stock for these years).

Table 9.5-3
Data Inputs for the Estimation of
Demand Equations for the Forklift Industry[26,27,28,29,30,31,32]

Variable	Unit of Measure
1. Time Trend	-
2. Price Index of Shipments for the Industrial Truck, Tractor, Trailer, and Stacker Mainery Industry (SIC 3537)	index
3. Quantity of Forklift Shipments	units
4. Price Index for the Manufacturing Industry	index
5. Price Index for the Wholesale Trade Industry	index
6. Price Index of Material Inputs	index
7. Production Worker Wages	millions of $
8. Implicit GDP Deflator	index
9. Production Worker Hours	thousands of worker hours
10. Investment	millions of $
11. Price Index of Investment	index
12. Real Capital Stock	millions of $1987
13. Real Gross Domestic Product	billions of $1987

SAS Release 8.2 for Windows was used to econometrically estimate the price elasticity of demand. Two-stage least squares econometric models were estimated for the forklift industry using the price indices of manufacturing and wholesale trade as the end-use products, respectively. Relying on price indices for entire sectors of the economy to represent specific end-use products is not ideal, but price data on specific products that forklifts are used to manufacture are not readily available. Additionally, forklifts are used in the production of a large variety of goods and it would therefore be difficult to determine which products to focus on for the estimation of demand elasticity. The data limitations are recognized and the demand elasticity estimates generated here are therefore, interpreted with caution.

Overall, the models using price indices for these end products were not successful. This may be due in part to the fact that price indices for entire sectors of the economy are not reliable instruments for the prices of the final products that forklifts are used to produce. The coefficient for the price index of shipments for SIC 3537 was not statistically different from zero in the model which included manufacturing. In the second model, which used the price index of wholesale trade in lieu of price index of manufacturing, the coefficient on the price index of shipments for SIC 3537 was significantly different than zero, but was equal to -5.8, an extremely large estimate of demand elasticity. The model results using the price indices of manufacturing and wholesale trade as the final product prices are reported in Table 9.5-4. with p-values listed below each coefficient estimate. Each of the coefficients reported has the anticipated sign, however not all of the estimates are significantly different from zero.

The price elasticity of demand estimate reflects an elastic demand for forklifts. Regulatory control costs are less likely to be paid by consumers of products with elastic demand when compared to products with inelastic demand, all other things held constant. Price increases for products with elastic price elasticity of demand lead to decreases in revenues for producers, however it does say anything with regard to producer profits.

A degree of uncertainty is associated with this method of demand estimation. The estimation is not robust since the model results vary depending upon the instruments used in the estimation process. For this reason, the above results are used as an indication that the elasticity of demand is elastic and we instead rely upon an assumed measure of -1.5 for the own-price elasticity of demand for forklifts.

Table 9.5-4
Derived Demand Coefficients Equations for the Forklift Industry

Variables	Estimation 1	Estimation 2
Own Price β ln(PI of Shipments for SIC 3537)	-3.03 (0.1113)	-5.76* (<.0001)
End-Use β_{FP} ln(PI of Manufacturing)	0.17 (0.9203)	
End-Use β_{FP} ln(PI of Wholesale Trade)		3.11* (0.0142)
ln(Real GDP)	3.44* (<.0001)	4.23* (<.0001)
F value	24.25* (<.0001)	32.96* (<.0001)
Adjusted R-Square	0.76	0.813

* statistically significant.

Supply Elasticity

Published sources of the price elasticity of forklift supply were not readily available. For this reason, an econometric analysis of the price elasticity of supply for forklifts was conducted using the same approach as the one used to estimate the supply elasticity for boat manufacturing described above.

The estimated model reflects the production function for forklifts, using annual time series data for the years from 1958 through 1999. The data used to estimate supply elasticity are enumerated in Table 9.5-5. The data for the price elasticity of supply estimation model includes: the value of domestic shipments of SIC 3537 in millions of dollars; the price index for value of domestic shipments (the value of domestic shipments deflated by the price index represents the quantity variable which is the dependent variable in the analysis); a technology time variable; production wages in millions of dollars; the implicit GDP deflator (used to deflate production wages), the material inputs in millions of dollars; the price index for value of materials; investment in millions of dollars; the price index of investment; and real net capital stock in millions of dollars.

Data to estimate the production function for the forklifts exclusively were largely unavailable; therefore, data for SIC code 3537 is utilized for each of the variables previously enumerated with the exception of the time variable. All data for the supply elasticity estimation were retrieved from the National Bureau of Economic Research-Center for Economic Studies (NBER-CES) Productivity Database and the U.S. Census Bureau's Annual Survey of Manufactures (ASM), with the exception of the technology time trend, the implicit GDP deflator, the price index for investment for SIC 3537 for the years 1997 through 1999, the price indices of shipments and material inputs for SIC 3537 for the years 1998 and 1999, and real capital stock for the years 1998 and 1999 (these data for real capital stock were not available). These variables (except the time trend and real capital stock for 1998 and 1999), were retrieved from the Bureau of Economic Analysis (BEA).

More specifically, the price index of shipments for SIC 3537 for the years 1998 and 1999 was retrieved from the BEA's Shipments of Manufacturing Industries. Similar to the boat manufacturing industry, a price index of material inputs for SIC 3537 was not available beyond 1997. We therefore relied upon a general price index for intermediate materials from BEA's Survey of Current Business. A price index for investment for SIC 3537 was also not available beyond 1996, so a general price index for capital equipment was used for the years 1997 - 1999 from the same source. Real capital stock for the years 1998 and 1999 was derived for SIC 3537 (see Equation 9-13 for the equation used to calculate real capital stock for these years).

Again, the capital stock variable was the most difficult variable to quantify for use in the econometric model. Ideally, this variable should represent the economic value of the capital stock actually used by each facility to produce forklifts for each year of the study. The most reasonable data for this variable would be the number of machine hours actually used to produce forklifts each year, but we do not possess this information. In lieu of machine hours data, the dollar value of net capital stock in constant 1987 prices, or real net capital stock, is used as a proxy for this variable.

Table 9.5-5
Data Inputs for the Estimation of Supply Elasticity for the Forklift Industry[33,3435,36,37,38]

Variable	Unit of Measure
1. Value of Shipments for the Industrial Truck, Tractor, Trailer, and Stacker Machinery Industry (SIC 3537)	millions of $
2. Price Index of Shipments for the Industrial Truck, Tractor, Trailer, and Stacker Machinery Industry (SIC 3537)	index
3. Time trend	-
4. Production Worker Wages	millions of $
5. Implicit GDP Deflator	index
6. Cost of Material Inputs	millions of $
7. Price Index of Material Inputs	index
8. Investment	millions of $
9. Price Index of Investment	index
8. Real Capital Stock	millions of 1987$

SAS Release 8.2 for Windows was used to estimate econometric estimates of the price elasticity of supply for the forklift manufacturing industry. A restricted least squares estimator was used to estimate the coefficients of the production function model. A log-linear specification was estimated with the sum of the α_i restricted to unity. This procedure is consistent with the assumption of constant returns to scale. The model was further adjusted to correct for first-order serial correlation using the Yule-Walker estimation method. The results of the estimated model are presented in Table 9.5-6 with p-values listed in parentheses below each coefficient estimate.

Table 9.5-6
Estimated Supply Model Coefficients for the Forklift Industry

Variables	Estimated Coefficients
ln(Time) (t)	0.1676 (.2066)
ln(Real Capital Stock) (K_t)	0.5833* (0.0070)
ln(Real Production Wages) (L_t)	1.1632* (<0.0001)
ln(Real Material Inputs) (M_t)	-0.7466* (0.0002)

* statistically significant

The coefficients for real capital and real production wages have the anticipated signs and are significant at a high level of confidence. The real material inputs coefficient does not have the anticipated sign and also tests significantly different from zero. Using the estimated coefficients and the formula for supply elasticity shown above, the price elasticity of supply for forklift manufacturing is derived to be 0.714. The calculation of statistical significance for this elasticity measure is not a straightforward calculation since the estimated function is non-linear. No attempt has been made to assess the statistical significance of the estimated elasticity. The corrections for serial correlation and the restricted model results yield inaccurate standard measures of goodness of fit (R^2). However, the model that is unrestricted and unadjusted for serial correlation has an R^2 of 0.99.

The estimated price elasticity of supply for the forklift manufacturing industry reflects that the industry in the United States will increase production of forklifts by 0.714 percent for every 1.0 percent increase in the price of this product. The preceding methodology does not directly estimate the supply elasticities for forklifts due to a lack of necessary data. The assumption implicit in the use of this price elasticity of supply estimate is that the supply elasticity of forklifts will not differ significantly from the price elasticity of supply for all products classified under SIC code 3537.

9.5.2.3 Price Elasticity Estimation for Snowmobiles

Demand Elasticity

The price elasticity of demand is an important input into the market model, and this information is required to characterize the demand for snowmobiles. Econometric estimation of the price elasticity of demand for snowmobiles was unsuccessful despite numerous model specifications and varied statistical techniques evaluated. A search of the literature did not provide snowmobile price elasticity of demand estimates. A study was conducted for the recreational boat industry in 1987.[39] This study estimates the price elasticity of demand for boats to be -1.78. The price elasticity of demand for a variety of pleasure boat categories were estimated. These estimates range from -1.4 to -2.17. For purposes of this analysis a price elasticity of demand for snowmobiles of -2 is postulated. Since this estimate does not relate specifically to the snowmobile market but to another category of recreational vehicles, and there are uncertainties associated with elasticity estimates, a sensitivity analysis of the impact of this estimate on model results is shown in the Appendix to Chapter 9 of this report.

Supply Elasticity

The price elasticity of supply for snowmobiles is a necessary input into the market model. A literature search did not provide any estimates of this required input. An econometric analysis is conducted and a value for this parameter is estimated. Several approaches were considered including a simultaneous equation approach, a production function approach and a simple supply function specification. Econometric results from the latter approach are presented. With this approach, the quantity of snowmobiles produced is hypothesized to be a function of the price of the product and the price of factors of production including the materials, labor, and capital as follows:

$$Q_t = f\,(P_t, P_{M\,t}, P_{L\,t}, P_{K\,t}) + u_t,$$

Where Q_t is the quantity of snowmobiles produced and sold in period t and $P_{M\,t}$, $P_{L\,t}$, $P_{K\,t}$ are the factor prices for inputs of production (materials, labor and capital, respectively) in period t. The data used to estimate the elasticity are enumerated in Table 9.5-7. Consistent time series data for the years 1986 through 2000 are used in the analysis. All price data have been restated into real values using the implicit GDP deflator. Snowmobile price and quantity data are provided by ISMA. The quantity of snowmobiles sold are restated to be values sold on a per household basis. Cost of production data for the snowmobile industry are largely unavailable. In lieu of the cost production data specific to snowmobile production, cost of production data for SIC 3799/NAICS code 336999 Other Transportation Equipment (includes snowmobiles as a product category) are used in the analysis as a proxy for the cost of production data for snowmobiles. The data used for the analysis are listed in Table 9.5-7.

Table 9.5-7
Data Inputs for the Estimation of
Supply Elasticity for the Snowmobile Industry[40,41,42,43,44,45,46,47]

Variable	Unit of Measure
1. Quantity of Snowmobiles Sold	units
2. US Households	number of households
3. Average price of snowmobiles sold	dollars
4. Price Index - Materials (SIC 3799 /NAICS 336999)	price index
5. Price Index - Investment (SIC 3799 /NAICS 336999)	price index
6. Wages per employee (SIC 3799 /NAICS 336999)	dollars
7. Real Implicit Gross Domestic Product Deflator	price index

SAS Release 8.2 for Windows was used to develop econometric estimates of the price elasticity of supply for the snowmobile industry. A log-log specification of the model was estimated. The price of capital was omitted from the model specification due to high correlation with the snowmobile price data. The model was further adjusted to correct for serial correlation using the Yule-Walker estimation method. Alternative lag periods were considered. The results of the estimated model are presented in Table 9.5-8 with related standard errors. Based upon this analysis the price elasticity of supply for the snowmobile industry is estimated to be 2.10.

Table 9.5-8
Estimated Supply Model Coefficients for the Snowmobile Industry

Variables	Estimated Coefficient	Standard Errors
Intercept	-16.4236	1.9094*
log (real price of snowmobiles)	2.1043	0.2441*
log (real wages per employee) (P_{Lt})	-0.2858	0.5479
log (real price of materials)(P_{Mt})	0.1617	0.1322
Total R-Square	0.9771	
Durbin-Watson Statistic	1.9728	

* Statistically significant at the 1% significance level.

The estimated model is statistically significant. The coefficient for real wages per employee has the anticipated signs but is not statistically significant. The coefficient for the materials variable does not have the anticipated sign and is not statistically significant. The coefficient for the price variable has the expected sign and is statistically significant. This value provides an estimate for the price elasticity of supply for snowmobiles. The estimated model is statistically significant. This value of 2.10 represents the price elasticity of supply used in the study. The uncertainty associated with this estimate is acknowledged. A sensitivity analysis of this model input is conducted in the appendix to this chapter.

9.5.2.4 Price Elasticity Estimation for All-Terrain Vehicles

Demand Elasticity

The price elasticity of demand is an important input to the market model, and this information is required to characterize the demand for ATVs. Econometric estimation of the price elasticity of demand for this market was unsuccessful despite numerous model specifications and varied statistical techniques evaluated. A search of the literature did not provide ATV price elasticity of demand estimates. A study was conducted for the recreational boat industry in 1987.[48] This study estimates the price elasticity of demand for boats to be -1.78. The price elasticity of demand for a variety of pleasure boat categories were estimated. These estimates range from -1.4 to -2.17. For purposes of this analysis, a price elasticity of demand for ATVs of -2 is postulated. Since this estimate does not relate specifically to the ATV market but another category of recreational vehicles and there are uncertainties associated with elasticity estimates in general, a sensitivity analysis of the impact of this estimate on model results is shown in the Appendix to Chapter 9 of this report.

Supply Elasticity

The price elasticity of supply is a necessary input in the market model. This estimate is required to characterize the way producers of ATVs respond to a change in the price of the product. A search of the economic literature was conducted without success. Econometric estimation of this variable were undertaken also without success. Numerous model specification and variable combinations were investigated, but the results were not satisfactory from a statistical perspective. The price elasticity of supply for off-highway motorcycles was estimated to be -0.93. Since the productive processes are similar for ATVs and off-highway motorcycles and many of the producers of ATVs also produce off-highway motorcycles, the supply elasticity for off-highway motorcycles appears to be a reasonable proxy for the supply elasticity for ATVs. A discussion of the techniques and data used to econometrically estimate this value follows in Section 9.5.2.5.

9.5.2.5 Price Elasticity Estimation for Off-Highway Motorcycles

Demand Elasticity

The price elasticity of demand is an important component of the market model and this information is required to characterize the demand for off-highway motorcycles. Econometric estimation of the price elasticity of demand for this market was unsuccessful despite numerous model specifications and varied statistical techniques evaluated. A search of the literature did not provide off-highway motorcycle price elasticity of demand estimates. A study was conducted for the recreational boat industry in 1987.[49] This study estimates the price elasticity of demand for boats to be -1.78. The price elasticity of demand for a variety of pleasure boat categories were estimated. These estimates range from -1.4 to -2.17. For purposes of this analysis a price elasticity of demand for off-highway motorcycles of -2 is postulated. Since this estimate does not relate specifically to the off-highway motorcycle market but another category of recreational vehicles and there are uncertainties associated with elasticity estimates in general, a sensitivity analysis of the impact of this estimate on model results is shown in the Appendix to Chapter 9 of this report.

Supply Elasticity

The price elasticity of supply for off-highway motorcycles is econometrically estimated. Data for the study is provided by the MIC and collected from publicly available sources. A description of the data used in the study, the modeling techniques used, and the model results are presented.

Methodology

A partial equilibrium market demand/supply model is specified as a system of interdependent equations in which the price and output of a product are simultaneously determined by the interaction of producers and consumers in the market. In simultaneous equation models, where variables in one equation feed back into variable in other equations, the error terms are correlated with the endogenous variables (price and output). In this case, single-equation ordinary least squares (OLS) estimation of individual equations will lead to biased and inconsistent parameter estimates. Thus, simultaneous estimation of this system to obtain elasticity estimates requires that each equation be identified through the inclusion of exogenous variable to control for shifts in the supply and demand curves over time.

The supply/demand system for OHM over time (t) is defined as follows:

$$Q_t^d = f(P_t, Z_t) + u_t$$

$$Q_t^s = (P_t, W_t) + v_t$$

$$Q_t^d = Q_t^s$$

The first equation above shows quantity demanded in year t as a function of price, P_t and an array of demand factors (e.g., measures of economic activity and substitute prices), and an error term, u_t. The second equation characterizes supply for the OHM market. The quantity supplied, Q_t^s in year t is a function of price and other supply factors, W_t (e.g., input prices) and an error term, v_t. The third equation specifies the equilibrium condition that quantity supplied equals quantity demanded in year t creating a system of three equations in three variables . The interaction of the specified market forces solves this system generating equilibrium values for the variables P_t* and $Q_t^* = Q_t^{d*} = Q_t^{s*.}$

Since the objective is to generate estimates of the supply equation for use in the economic model, the EPA employed the two-stage least squares (2SLS) regression procedure to estimate only the parameters of the supply equation. Similar techniques for the demand equation were unsuccessful. EPA specified the logarithm of the quantity supplied as a linear function of the logarithm of the price so that the coefficient on the price variable yields the estimate of the constant elasticity of supply for OHM. All prices employed in the estimation process were deflated by the gross domestic product (GDP) implicit price deflator to reflect real rather than nominal prices. The first stage produces fitted (or predicted) values for the price variables that are, by definition, highly correlated with the error term. In the second stage, these fitted values are then employed as observations of the right hand side price variable in the supply function. This fitted value is uncorrelated with the error term by construction and thus does not incur the endogeneity bias.

Data

Price and quantity data were provided by MIC for the period 1990 through 2000. Thus the study uses annual data for the period 1990 through 2000. For the supply equation estimated, supply is postulated to be a function of price, a trend variable to recognize technology changes over time, and the price of inputs of production. A number of factor prices were considered including the price of materials, labor, and capital. Unfortunately these inputs price are some cases highly correlated. For this reason, the price of materials is used in estimation. A listing of the data used in the analysis and the source of the data are shown in Table 9.5-9. All data used in the analysis are deflated to real values using the real gross domestic product implicit price deflator. Sales quantities and income values are restated to per US household values. All values are restated to natural logs.

Table 9.5-9
Data Inputs for Off-Highway Motorcycle Supply Estimation[50,51,52,53,54,55,56,57]

Variable	Unit of Measure
1. Quantity of OHM sold	units
2. US households	number
3. Average price OHM	dollars
4. Time trend	N/A
5. Price index for materials used in production	price index
6. Price of a substitute product (SIC 3799/NAICS 336999)	price index
7. Disposable household income	dollars
8. Real implicit GDP deflator	price index

Results

The results of the supply estimation are shown in Table 9.5-10

Table 9.5-10
Estimated Supply Model for the Off-Highway Motorcycle Industry

Parameter	Parameter Estimate	Standard Error
Intercept	-10.7632*	0.179407
log (Trend Variable)	-0.03399*	0.005626
log (Real Price)	0.93323*	0.017468
log (Price of materials used in production of OHM)	-0.36977	0.294203
Adjusted R Square	0 .9996	
F-Value	8867.69*	
Durbin Watson	1.65	

* Statistically significant at the 1% significance level.

The estimated equation and coefficients have the expected sign and are statistically significant at a 1% significance level with the exception of the cost of materials variable. While the coefficient for the price of materials variable has the expected sign, it is not statistically significant. The coefficient for the natural log of the real price variable of 0.93 is the estimate of the price elasticity of supply for the off-highway motorcycle market. The uncertainty surrounding this estimate is recognized and a sensitivity analysis of this model input is conducted in the appendix to this chapter.

9.6 Marine

The following section describes the baseline characterization of the market in the year 2001, the per unit regulatory control costs incurred by producers of recreational diesel marine vessels, and the economic impacts that would have resulted had the emissions control program been implemented in the baseline year. We also examine the economic impacts on the diesel inboard cruiser market using baseline year data for each change in the per unit control costs that occurs. This section concludes with a comparison of the stream of engineering costs and estimated welfare losses (excluding fuel efficiency gains) projected to occur after the regulation's implementation. No fuel efficiency gains are projected to occur from the standard affecting diesel recreational marine vessels, therefore the social costs (surplus losses net fuel cost savings) are equal to the surplus losses projected from the model.

9.6.1 Marine Baseline Market Characterization

Inputs to the economic analysis are a year 2001 baseline characterization of the diesel inboard cruiser market that includes the domestic quantity produced, quantity of imports, baseline market price, demand elasticity, and domestic and foreign supply elasticity measures. Table 9.6-1 provides the baseline data on the U.S. diesel inboard cruiser market used in this analysis.

Table 9.6-1
Baseline Characterization of the U.S. Diesel Inboard Cruiser Market: 2001

Inputs	Baseline Observation
Market price ($/boat)	$341,945.00
Market output (boats)	8435
Domestic	8098
Foreign	337
Elasticities	
Domestic supply (estimated)	1.57
Foreign supply (assumed)	1.57
Demand (previously estimated)	-1.44

The total market output of diesel inboard cruiser marine vessels was derived from data taken from publications of the National Marine Manufacturers Association[58,59]. EPA projected the quantity of CI marine engines for the years 1998 through 2030 based upon NMMA's historical data on the quantity of inboard cruisers sold in the U.S. For the year 2001, EPA's projection shows that 16,068 engines were sold domestically. This total includes those engines sold in the U.S. whether they were produced domestically or abroad. A simplifying assumption has been made that all of these engines are used in inboard cruisers, though we acknowledge that there is an extremely small fraction of these engines that are used in inboard runabouts (approximately 2 percent) and an even smaller fraction used in marine vessels with outboard engine configurations.[60] A majority (95 percent) of inboard cruisers contain two engines.[61] Using this information, we find that the 16,068 recreational diesel marine engines sold in 2001 would yield 8,435 diesel inboard cruisers.

Market output is not partitioned into domestically produced and imported quantities of recreational diesel marine engines. In order to determine the share of imported boats, historical import quantities of inboard cruisers were compared with the domestically produced quantities reported in Table 2.1-7 for the years 1992 to 2000[62]. On average, imported inboard cruisers were equal to about 4 percent of the inboard cruisers produced and sold in the U.S. This information was used to partition the total quantity of diesel inboard boats for the year 2001.

The price of diesel inboard cruisers was taken to be equal to the average retail price of all inboard cruisers sold in the year 2001. NMMA quotes this price at $341,945.[63] The estimates of demand and supply elasticity have been discussed in detail in Section 9.5.2.1. A separate estimate of foreign supply elasticity has not been carried out. For modeling purposes, we assume that the foreign supply elasticity is equal to the domestic supply elasticity.

9.6.2 Marine Control Costs

In order to determine a per diesel inboard cruiser cost over the years 2006 to 2030 for use in the economic analysis, the future stream of engineering costs (without fuel savings) provided in Chapter 7 is divided by the number of boats EPA projected from the NMMA data. This yields a stream of average cost per diesel inboard cruiser. As stated in the section above, the EPA projected the quantity of recreational diesel marine engines sold in the U.S. for the years 1998 through 2030. Using these engine quantities and the fact that approximately 95 percent of inboard cruisers contain two engines, we developed a projected stream of domestic diesel inboard cruiser sales. The total stream of engineering costs from Chapter 7, the projected number of diesel inboard cruisers, and the average regulatory cost per boat are provided in Table 9.6-2. During the initial years of implementation, the per unit costs change but by 2014, they are projected to remain the same.

Table 9.6-2
Projected Future Stream of Engineering Costs ($\$10^3$), Quantity of Diesel Inboard Cruisers, and Per Diesel Inboard Cruiser Regulatory Costs

Year	Estimated Engineering Costs	Projected Quantity of Diesel Inboard Cruisers	Cost Per Diesel Inboard Cruiser
2006	$7,806.0	9665	$808
2007	$8,365.3	9913	$844
2008	$8,573.8	10159	$844
2009	$9,413.5	10407	$905
2010	$9,637.0	10653	$905
2011	$5,213.4	10899	$478
2012	$5,176.7	11145	$464
2013	$5,290.8	11390	$464
2014	$4,958.1	11636	$426
2015	$5,062.7	11882	$426
2016	$5,167.7	12128	$426
2017	$5,272.7	12374	$426
2018	$5,377.6	12621	$426
2019	$5,482.6	12867	$426
2020	$5,587.6	13113	$426
2021	$5,692.5	13360	$426
2022	$5,797.5	13606	$426
2023	$5,902.5	13853	$426
2024	$6,007.4	14099	$426
2025	$6,112.4	14345	$426
2026	$6,217.2	14591	$426
2027	$6,322.0	14837	$426
2028	$6,426.9	15083	$426
2029	$6,531.7	15329	$426
2030	$6,636.5	15575	$426

9.6.3 Marine Economic Impact Results

The economic impacts of the emissions control program for recreational diesel marine vessels are estimated for each year in which the per vessel regulatory costs change, assuming the baseline year 2001 price and quantity. Though we possess projected quantities of diesel inboard cruiser marine vessels through the year 2030, we do not have future year prices. We are therefore unable to estimate the economic impacts of the future costs assuming future year quantities and prices. For this reason, we rely upon the most current year of data to inform the model when we impose the future costs per vessel on producers. Using baseline year data allows us to estimate relative changes in price and quantity as opposed to absolute changes. The estimated percent changes in price and quantity, the changes consumer and producer surplus, and the total loss in surplus are presented for various years in Tables 9.6-3 and 9.6-4.

Table 9.6-3
Price and Quantity Changes for the Diesel Inboard Cruiser Market*

Impact Measure	2006	2007/8	2009/10	2011	2012/13	2014+
Cost Per Unit	$808	$844	$905	$478	$464	$426
Change in Market Price	0.12%	0.13%	0.14%	0.07%	0.07%	0.06%
Change in Market Output	-0.18%	-0.19%	-0.20%	-0.10%	-0.10%	-0.09%
Domestic	-0.18%	-0.19%	-0.20%	-0.10%	-0.10%	-0.09%
Foreign	-0.18%	-0.19%	-0.20%	-0.10%	-0.10%	-0.09%

*Results are the same for the years 2007 and 2008, 2009 and 2010, and for the years 2012 and 2013. They are also the same for the years 2014 and beyond. These results are not reported in separate columns to avoid repetition. Results are based on baseline year 2001 market conditions and fuel cost savings are not included.

Table 9.6-4
Annual Losses in Consumer and
Producer Surplus and for the Diesel Inboard Cruiser Market*

Impact Measure	2006	2007/8	2009/10	2011	2012/13	2014+
Loss in CS** ($\$10^3$)	$3,551.8	$3,709.9	$3,977.7	$2,101.9	$2,040.4	$1,873.4
Loss in PS*** ($\$10^3$)	$3,251.9	$3,396.4	$3,641.1	$1,925.8	$1,869.5	$1,716.6
Domestic	$3,122.0	$3,260.7	$3,495.6	$1,848.9	$1,794.8	$1,648.0
Foreign	$129.9	$135.7	$145.5	$76.9	$74.7	$68.6
Loss in Surplus ($\$10^3$)	$6,083.7	$7,106.3	$7,618.8	$4,027.7	$3,909.9	$3,590.0

*Results are the same for the years 2007 and 2008, 2009 and 2010, and for the years 2012 and 2013. They are also the same for the years 2014 and beyond. These results are not reported in separate columns to avoid repetition. Results are based on baseline year 2001 market conditions and fuel cost savings are not included.
** CS refers to consumer surplus and is rounded to the nearest hundredths. For a description of the change in consumer surplus, see Section 9.2.2
*** PS refers to producer surplus and is rounded to the nearest hundredths. For a description of the change in producer surplus, see Section 9.2.2.

As Table 9.6-3 shows, the relative increases in price due to the regulatory costs are less than two-tenths of a percent while the reductions in output are less than one-quarter of a percent. These impacts are considered minimal. Also notable is that the percent changes in price and quantity peak in the years 2009 and 2010 but then are smaller further out into the future. The percent reduction in quantity is the same for both domestic and foreign output because it has been assumed that domestic and foreign supply have the same price elasticity.

Table 9.6-4 presents the loss in consumer surplus, the loss in producer surplus, and the loss in surplus (equal to the sum of the changes in consumer and producer surplus). These results show that the losses in consumer and producer surplus are approximately equal in size, though the loss in producer surplus is slightly less than the loss in consumer surplus. Consumer surplus losses range from a high of just under $4 million to a low of $1.9 million, while the losses in producer surplus vary from $3.6 million to $1.7 million. Like the price and quantity changes, these measures are largest in the years 2009 and 2010. They then decline to their lowest value in 2014 and beyond.

9.6.4 Marine Engineering Cost and Surplus Loss Comparison

Table 9.6-5 presents the future stream of estimated engineering costs holding quantity constant to the baseline year quantity and the loss in surplus that has been estimated from the economic impact model. Because economic modeling takes into account consumer and producer behavior, the estimated surplus losses are less than the engineering costs under a perfectly competitive market setting. In this case, surplus losses are, on average equal to over 99 percent of the calculated engineering costs. Note that the costs provided in this table are not discounted.

Based upon the annual ratio of surplus losses to engineering costs holding quantity constant to baseline year quantity, a projection of surplus losses over the future year stream is calculated from the future stream of engineering costs that appear in Chapter 7. The projected future stream of surplus loss is calculated by multiplying the annual ratio by the future stream of engineering costs and is presented in Table 9.6-6. Again, these costs are not discounted.

9.6.5 Marine Economic Impact Results with Fuel Cost Savings

No fuel savings are projected for the recreational diesel marine engine category, therefore there are no alternative results to present for this vehicle category. The stream of social costs for this vehicle category are equal to the stream of estimated surplus losses shown in Table 9.6-6.

Table 9.6-5
Interim Engineering Cost and Surplus Loss Comparison for the Recreational Diesel Marine Vessel Market Based on Year 2001 Quantity (Q =8,435 inboard cruisers)

Year	Estimated Engineering Costs	Estimated Surplus Loss
2006	$6,812,980	$6,803,645
2007	$7,119,006	$7,106,227
2008	$7,119,006	$7,106,227
2009	$7,630,744	$7,618,828

2010	$7,630,982	$7,618,828
2011	$4,035,120	$4,027,788
2012	$3,918,352	$3,909,937
2013	$3,918,326	$3,909,937
2014	$3,594,386	$3,590,020
2015	$3,594,365	$3,590,020
2016	$3,594,403	$3,590,020
2017	$3,594,441	$3,590,020
2018	$3,594,328	$3,590,020
2019	$3,594,365	$3,590,020
2020	$3,594,401	$3,590,020
2021	$3,594,436	$3,590,020
2022	$3,594,470	$3,590,020
2023	$3,594,365	$3,590,020
2024	$3,594,399	$3,590,020
2025	$3,549,432	$3,590,020
2026	$3,594,373	$3,590,020
2027	$3,594,444	$3,590,020
2028	$3,594,388	$3,590,020
2029	$3,594,456	$3,590,020
2030	$3,594,401	$3,590,020

Table 9.6-6
Engineering Costs and Surplus Loss Comparison for
the Recreational Diesel Marine Vessel Market

Year	Estimated Engineering Costs	Estimated Surplus Loss
2006	$7,806,010	$7,795,314
2007	$8,365,319	$8,350,303
2008	$8,573,839	$8,558,165
2009	$9,413,530	$9,398,831
2010	$9,637,035	$9,621,686
2011	$5,213,411	$5,203,938
2012	$5,176,672	$5,165,555
2013	$5,290,764	$5,279,437
2014	$4,958,052	$4,952,029
2015	$5,062,713	$5,056,593
2016	$5,167,682	$5,161,380

2017	$5,272,652	$5,266,167
2018	$5,377,623	$5,371,178
2019	$5,482,592	$5,475,965
2020	$5,587,562	$5,580,752
2021	$5,692,532	$5,685,539
2022	$5,797,503	$5,790,326
2023	$5,902,472	$5,895,337
2024	$6,007,442	$6,000,124
2025	$6,112,413	$6,104,911
2026	$6,217,227	$6,209,698
2027	$6,322,042	$6,314,262
2028	$6,426,858	$6,419,049
2029	$6,531,673	$6,523,512
2030	$6,636,488	$6,628,400

9.7 Large SI Engines

As described in Chapter 2 and illustrated in Table 6.2.2-1, Large SI engines are used in nearly 50 different applications ranging from fairly small, low horsepower equipment used in lawncare applications to agricultural and construction equipment exceeding 100 horsepower. Forklifts are clearly the dominant application in this category, accounting for about 52 percent of the 2000 populations of Large SI engines. The next largest applications are generators, accounting for about 15 percent, and commercial turf applications, accounting for about 6 percent. Forklifts are also used more than other applications, for about 15,000 hours over the average operating life of the equipment, compared to about 6,000 hours for the next most-used applications (e.g., aerial lifts, refrigeration/AC, cranes). Similarly, forklifts accounted for nearly 81 percent of the NOx, 64 percent of the HC, 54 percent of the CO, and 76 percent of the PM emissions from Large SI engines in 2000. Because of their dominant position in this category, the following economic impact analysis focuses on the forklift segment. Specifically, we estimate the change in price and quantity, and the sum of consumer and producer surplus losses only for forklifts. To estimate the total social costs/gains for Large SI, we use the engineering costs to approximate the sum of consumer and producer surplus losses for Large SI engines other than forklifts. This approach slightly overestimates the surplus losses for the category since engineering costs are higher than surplus losses.

While it would be possible to perform a market analysis for each of the Large SI applications, we chose not to. Annual sales in some of these categories are so small that the results of separate analysis would not be meaningful and would imply a degree of precision that would not be reflected in the data inputs. Grouping the applications by horsepower, load factor, or usage rates would not necessarily reduce the complexity of the analysis because equipment that use similar size engines are often not used with the same intensity. In addition, their markets may not necessarily share the same demand and supply characteristics.

The results of our economic impact analysis for forklifts with regard to price and quantity changes is not meant to be interpreted as representing the estimated impacts for all Large SI engines. Changes in price and quantity are likely to be different for applications other than forklifts due to differences in their market characteristics.

The remainder of this section describes the baseline characterization of the forklift market in the year 2000, the regulatory control costs incurred by producers of forklifts, and the economic impacts that would have resulted had the emissions control program been imposed in the baseline year. We examine the economic impacts on the forklift market using the baseline year data for each change in the per unit control costs that occurs. A comparison is then made between the engineering cost and surplus loss streams projected to occur after the regulation's implementation. This initial comparison of the cost streams assumes no fuel cost savings. A comparison is then made between engineering costs and social costs/gains accounting for fuel cost savings of the emissions control program. Finally, an estimate of the social costs/gains for Large SI engines other than forklifts is presented, using engineering costs as a substitute for consumer and producer surplus losses.

9.7.1 Forklift Baseline Market Characterization

Inputs to the economic analysis are a year 2000 baseline characterization of the forklift market that includes the domestic quantity produced, quantity of imports, baseline market price, demand elasticity, and domestic and foreign supply elasticity measures. Table 9.7-1 provides the baseline data on the U.S. forklift market used in this analysis.

Table 9.7-1
Baseline Characterization of the U.S. Forklift Market: 2000

Inputs	**Baseline Observation**
Market price ($/forklift)	$26,380.00
Market output (forklifts)	65000
Domestic	48750
Foreign	16250
Elasticities	
Domestic supply (estimated)	0.714
Foreign supply (assumed)	0.714
Demand (assumed)	-1.5

The total quantity of Large SI engines sold in the U.S. was retrieved from the PSR database, which contains projections of U.S. sales of Large SI engines for the year 2000 and the years 2004 through 2030. Though we possess year 2000 quantity of imports and domestic shipments of forklifts from the International Trade Commission and the Industrial Truck Association, respectively, we have chosen to rely on PSR's database to maintain consistency with the projections of forklift engines used in other sections of this rule's analysis. Based on the PSR database, we have determined that approximately 50 percent of the population of Large SI engines are used in the production of forklifts. This quantity of engines is taken as a measure of the quantity of forklifts sold, based on the assumption that each forklift contains one engine.

The PSR database does not separate the quantity of forklift engines that are produced and used in the U.S. from those that are imported. In order to determine the share of imported forklifts of this total, historical import quantities of forklifts were compared with domestically produced quantities. On average, imported forklifts were equal to about 25 percent of forklifts produced in the U.S. in the past 10 years. This information was used to partition the total quantity of forklifts listed in the PSR database into the share of domestically produced forklifts and the share of imports for the year 2000.

The price of forklifts used in the model is taken as the year 2000 price of a representative model of Class 5 forklift. The year 2000 price of Nissan's JC50 pneumatic tire IC engine forklift was $26,380 and it is used as the nationwide market price of forklifts. It is acknowledged that there are a variety of Class 4, 5, and 6 forklifts with varying prices. The range of prices of these forklifts are discussed in Chapter 2. However, we require a single price to operationalize the perfectly competitive national-level market model used to examine the economic impacts of this rule on the U.S. forklift market.

The estimates of demand and supply elasticity have been discussed in detail in Section 9.5.2.2. A separate estimate of foreign supply elasticity has not been carried out. For modeling purposes, we assume that the foreign supply elasticity is equal to the domestic supply elasticity.

9.7.2 Forklift Control Costs

The emissions control costs used in the economic analysis are developed and reported in Chapter 5. In this section, we briefly recount the estimated regulatory cost per forklift that are used to in the model. The regulatory cost per unit faced by forklift producers leads to a parallel shift inward of the market supply curve. As stated earlier, the compliance costs per forklift are projected to change in future years as different phases of the emissions control program are implemented and as the learning curve is applied (see Chapter 5 for a discussion of the learning curve). The regulatory cost per forklift are presented in Table 9.7-2 for the years in which they change.

Table 9.7-2
Regulatory Costs Per Forklift

Year	Cost Per Forklift	Cost Description
2004/5	$610	Phase 1/year 1 costs
2006	$493	Phase 1/year 3 costs
2007/8	$537	Phase 1/year 3 costs + Phase 2/year 1 costs
2009/10/11	$418	Phase 1/year 6 costs + Phase 2/year 3 costs
2012 - 2030	$390	Phase 1/year 6 costs + Phase 2/year 6 costs

Economic impacts are estimated based upon these costs. In the model, the baseline year quantity and price of forklifts are used and the per unit costs are imposed on the model to determine price, quantity, and consumer and producer surplus changes.

9.7.3 Forklift Economic Impact Results

The economic impacts of the regulation on the forklift market are estimated for each year in which the per engine regulatory costs change, assuming the baseline year 2000 price and quantity. We possess projected quantities of forklifts through the year 2030, however we do not have projected future year prices. Without this information, we cannot estimate the economic impacts of the future costs assuming future year quantities and prices. We instead rely upon the most current year of data to inform the model when we impose the future costs per forklift on producers. Using baseline year data allows us to estimate relative changes in price and quantity as opposed to absolute changes. The estimated percent changes in price and quantity, the losses in consumer and producer surplus, and total surplus loss are presented for various years in Tables 9.7-3 and 9.7-4. These results do not account for fuel cost savings that may arise from this emissions control program.

Table 9.7-3
Price and Quantity Changes for the Forklift Market*

Impact Measure	2004/5	2006	2007/8	2009	2012
Cost Per Unit	$610	$493	$537	$418	$390
Change in Market Price	0.75%	0.60%	0.66%	0.51%	0.48%
Change in Market Output	-1.12%	-0.90%	-0.98%	-0.77%	-0.72%
Domestic	-1.12%	-0.90%	-0.98%	-0.77%	-0.72%
Foreign	-1.12%	-0.90%	-0.98%	-0.77%	-0.72%

*Results are the same for the years 2004 and 2005, 2007 and 2008, and the years 2009, 2010, and 2011. They are also the same for the years 2012 and beyond. These results are not reported in separate columns to avoid repetition. Results are based on baseline year 2000 market conditions and fuel cost savings are not included.

Table 9.7-4
Annual Losses in Consumer and Producer Surplus for the Forklift Market*

Impact Measure	2004/5	2006	2007/8	2009	2012
Loss in CS (10^3)**	$12,715.3	$10,287.6	$11,201.2	$8,728.6	$8,146.0
Loss in PS* (10^3)**	$26,412.4	$21,416.3	$23,299.1	$18,196.2	$16,990.5
Domestic	$19,809.3	$16,062.2	$17,474.3	$13,647.2	$12,742.9
Foreign	$6,603.1	$5,354.1	$5,824.8	$4,549.0	$4,247.6
Loss in Surplus (10^3)	$39,127.7	$31,703.9	$34,500.3	$26,924.8	$25,136.5

*Results are the same for the years 2004 and 2005, 2007 and 2008, and the years 2009, 2010, and 2011. They are also the same for the years 2012 and beyond. These results are not reported in separate columns to avoid repetition. Results are based on baseline year 2000 market conditions and fuel cost savings are not included.
** CS refers to consumer surplus and is rounded to the nearest hundredths. For a description of the change in consumer surplus, see Section 9.2.2
*** PS refers to producer surplus and is rounded to the nearest hundredths. For a description of the change in producer surplus, see Section 9.2.2.

For the per forklift engine costs resulting from the implementation of the emissions control program, the relative increases in price over the future time period examined are three-quarters of one percent or less. By the year 2014, the relative price increase falls to approximately one-half of one percent. The percent reductions in the market quantity of forklifts are initially projected to be slightly greater than one percent, but by 2006, the relative reduction in market quantity falls below one percent. Though these impacts are larger than those in the inboard diesel cruiser market, they are still considered minimal. Note that the percent reduction in quantity is the same for both domestic and foreign output because it has been assumed that domestic and foreign supply have the same price elasticity.

Table 9.7-4 above presents the loss in consumer surplus, the loss in producer surplus, and the total loss in surplus (equal to the sum of the changes in consumer and producer surplus) without fuel cost savings. As the table shows, the consumer surplus loss is approximately half the size of the loss in producer surplus. Consumer surplus losses range from $12.7 million in year 2004 when the rule is first implemented to $8.1 million in 2012 and the years beyond through 2030. The losses in producer surplus are at their largest at $26.4 million in the first year of implementation and they reach their lowest value in 2012 and the years beyond at just below $17 million. Note that the annual surplus loss associated with the forklift market declines as the per forklift engine costs fall. Loss in surplus is equal to $39.1 million in 2004 and it falls to $25.1 million by 2012.

9.7.4 Forklift Engineering Cost and Surplus Loss Comparison

This section presents a comparison of the future stream of engineering costs (excluding fuel cost savings) and surplus losses for the forklift market. In Table 9.7-5, we first present an interim comparison of the estimated engineering costs, holding quantity constant to the baseline year quantity, with the surplus losses that were estimated from the economic impact model. Because economic modeling takes into account consumer and producer behavior, the estimated loss in surplus is less than the engineering costs under a perfectly competitive market setting. In this case, the annual surplus losses are, on average, equal to 98 to 99 percent of the calculated engineering costs. The cost numbers in this table and Table 9.7-6 are not discounted.

Based upon a ratio of the loss in surplus to engineering costs, holding baseline quantity constant, a projection of the surplus loss over the future year stream is calculated from the future stream of engineering costs that appear in Chapter 7. This projection of the future stream of surplus losses is compared to the future stream of engineering costs in Table 9.7-6. Note that these results are not discounted nor do they account for fuel cost savings.

9.7.5 Forklift Economic Impact Results with Fuel Cost Savings

In Table 9.7-7, the social costs/gains are calculated by adding the annual savings in fuel costs (presented initially in Chapter 7) to the projected annual surplus loss. These social gains are compared to the engineering costs with fuel efficiency gains. As you can see from this table, the emissions control program is expected to yield social gains rather than losses beyond the initial year of implementation. Only the initial year of implementation results in a social loss from this regulation for the forklift market.

Table 9.7-5
Interim Engineering Cost and Surplus Loss Comparison for the Forklift Market Based on Year 2000 Quantity (Q = 65,000 forklifts)

Year	Estimated Engineering Costs	Estimated Surplus Loss
2004	$39,645,853	$39,127,756
2005	$39,645,853	$39,127,756
2006	$32,047.483	$31,703,880
2007	$34,914,619	$34,500,273
2008	$34,914,619	$34,500,273
2009	$27,143,050	$26,924,774
2010	$27,143,050	$26,924,774
2011	$27,143,050	$26,924,774
2012	$25,329,069	$25,136,527
2013	$25,329,069	$25,136,527
2014	$25,329,069	$25,136,527
2015	$25,329,069	$25,136,527
2016	$25,329,069	$25,136,527
2017	$25,329,069	$25,136,527
2018	$25,329,069	$25,136,527
2019	$25,329,069	$25,136,527
2020	$25,329,069	$25,136,527
2021	$25,329,069	$25,136,527
2022	$25,329,069	$25,136,527
2023	$25,329,069	$25,136,527
2024	$25,329,069	$25,136,527
2025	$25,329,069	$25,136,527
2026	$25,329,069	$25,136,527
2027	$25,329,069	$25,136,527
2028	$25,329,069	$25,136,527
2029	$25,329,069	$25,136,527
2030	$25,329,069	$25,136,527

Table 9.7-6
Engineering Cost and Surplus Loss Comparison for the Forklift Market without Fuel Cost Savings

Year	Estimated Engineering Costs	Estimated Surplus Loss
2004	$44,403,355	$43,823,087
2005	$45,592,731	$44,996,919
2006	$37,816,030	$37,410,578
2007	$42,246,689	$41,745,330
2008	$43,294,128	$42,780,339
2009	$34,471,674	$34,194,463
2010	$35,285,965	$35,002,206
2011	$36,100,257	$35,809,949
2012	$34,447,534	$34,185,677
2013	$35,207,406	$34,939,773
2014	$35,967,278	$34,693,868
2015	$36,727,150	$36,447,964
2016	$37,487,022	$37,202,060
2017	$38,246,894	$37,956,156
2018	$39,006,766	$38,710,252
2019	$39,766,638	$39,464,347
2020	$40,526,510	$40,218,443
2021	$41,286,382	$40,972,539
2022	$42,046,254	$41,726,635
2023	$42,806,126	$42,480,731
2024	$43,565,998	$43,234,826
2025	$44,325,871	$43,988,922
2026	$45,085,743	$44,743,018
2027	$45,845,615	$45,497,114
2028	$46,605,487	$46,251,210
2029	$47,365,359	$47,005,305
2030	$48,125,231	$47,759,401

Table 9.7-7
Engineering and Social Cost Comparison
for the Forklift Market with Fuel Cost Savings

Year	Estimated Engineering Costs with Fuel Cost Savings	Estimated Social Costs/Gains (Surplus Loss - Fuel Savings)*
2004	$7,305,024	$6,724,756
2005	($29,112.307)	($29,708,119)
2006	($74,949,193)	($75,354,645)
2007	($107,719,996)	($108,221,355)
2008	($142,910,106)	($143,423,895)
2009	($186,910,292)	($187,187,502)
2010	($220,128,020)	($220,411,779)
2011	($248,696,789)	($248,987,097)
2012	($263,429,050)	($263,690,906)
2013	($273,365,256)	($273,632,888)
2014	($282,258,050)	($282,531,460)
2015	($290,155,574)	($290,434,760)
2016	($297,059,701)	($297,344,663)
2017	($303,544,978)	($303,835,716)
2018	($309,618,970)	($309,915,484)
2019	($315,291,768)	($315,594,059)
2020	($320,384,517)	($320,692,585)
2021	($325,478,111)	($325,791,955)
2022	($330,572,494)	($330,892,113)
2023	($336,095,973)	($336,421,369)
2024	($341,680,638)	($342,011,810)
2025	($347,267,003)	($347,603,952)
2026	($352,193,263)	($352,535,988)
2027	($357,123,770)	($357,472,271)
2028	($362,058,551)	($362,412,827)
2029	($366,996,593)	($367,356,646)
2030	($371,938,165)	($372,303,995)

* ( ) represents a negative cost (social gain). Cost estimates are based upon 2000$.

9.7.6 Economic Impacts - Other Large SI Engines

To complete the analysis of the economic impacts of this rulemaking on Large SI engines, we used engineering costs as a surrogate for consumer and producer surplus losses. As noted above, this approach slightly overestimates the surplus losses, suggesting that the standards will have a slightly larger total impact on consumers and producers. This approach does not allow disaggregating to determine the portion of the costs borne by consumers and the portion borne by producers. The estimated fuel cost savings for Large SI engines other than forklifts are based on the methodology used for forklifts. The results of this analysis are contained in Table 9.7-8. According to this analysis, the emissions control program is expected to yield social gains rather than losses beyond the first two years of implementation.

Table 9.7-8
Engineering Cost and Surplus Loss Comparison for Large SI Engines Other Than Forklifts

Year	Estimated Surplus Loss (Engineering Costs)	Estimated Fuel Savings	Estimated Social Costs/Gains (Surplus Loss - Fuel Savings)*
2004	$44,403,355	($15,627,144)	$28,776,211
2005	$45,592,731	($28,275,848)	$17,316,883
2006	$37,816,030	($40,160,970)	($2,344,940)
2007	$42,246,689	($48,976,681)	($6,729,992)
2008	$43,294,128	($56,624,806)	($13,330,678)
2009	$34,471,674	($63,712,068)	($29,240,394)
2010	$35,285,965	($70,327,718)	($35,041,753)
2011	$36,100,257	($76,172,728)	($40,072,471)
2012	$34,447,534	($81,521,871)	($47,074,337)
2013	$35,207,406	($86,460,491)	($51,253,085)
2014	$35,967,278	($90,759,859)	($54,792,581)
2015	$36,727,150	($94,347,999)	($57,620,849)
2016	$37,487,022	($97,888,686)	($60,401,664)
2017	$38,246,894	($101,329,714)	($63,082,820)
2018	$39,006,766	($104,666,222)	($65,659,456)
2019	$39,766,638	($107,916,691)	($68,150,053)
2020	$40,526,510	($111,080,698)	($70,554,188)
2021	$41,286,382	($114,155,459)	($72,869,077)
2022	$42,046,254	($117,123,427)	($75,077,173)
2023	$42,806,126	($117,123,427)	($74,317,301)
2024	$43,565,998	($122,621,375)	($79,055,377)
2025	$44,325,871	($125,268,725)	($80,942,854)
2026	$45,085,743	($128,102,036)	($83,016,293)
2027	$45,845,615	($130,896,877)	($85,051,262)
2028	$46,605,487	($133,533,546)	($86,928,059)
2029	$47,365,359	($135,988,425)	($88,623,066)
2030	$48,125,231	($138,409,359)	($90,284,128)

9.8 Snowmobiles

The following section describes the baseline characterization of the snowmobile market in the year 2001, the regulatory control costs incurred by producers of snowmobiles, and the economic impacts that would have resulted had the emissions control program been imposed in the baseline year. We examine the economic impacts on the snowmobile market using the baseline year data for each change in the per unit control costs that occurs. A comparison is then made between the engineering cost and surplus loss streams projected to occur after the regulation's implementation. This initial comparison of the cost streams assumes no fuel cost savings. A comparison is then made between engineering costs and social costs/gains accounting for fuel cost savings of the emissions control program.

9.8.1 Snowmobile Baseline Market Characterization

Inputs to the economic analysis are provide a baseline characterization for the snowmobile market for the year 2001. Baseline market data include the domestic quantity produced, quantity of imports, baseline market price, demand elasticity, and domestic and foreign supply elasticity measures. Table 9.8-1 provides the baseline data for the U.S. snowmobile market used in this analysis.

Table 9.8-1
Baseline Characterization of the U.S. Snowmobile Market: 2001[64,65]

Inputs	Baseline Observation
Market price ($/snowmobile)	$6,360.00
Market output (snowmobiles)	140,629
Domestic	80,015
Foreign	60,614
Elasticities	
Domestic supply (estimated)	2.1
Foreign supply (assumed)	2.1
Demand (assumed)	-2

The market sales and quantity data are available from the ISMA website. Import and export estimates are based upon data from the PSR. PSR lists vehicles that are imports. For the year 2000, approximately 60 percent of snowmobiles produced by the 4 largest producers were produced domestically by Polaris and Arctic Cat. It is assumed that the production relationship between imports and exports is mirrored in sales for 2001. Based upon this import ratio, we estimate that approximately 61 thousand of the snowmobiles sold in the US in 2001 were imported.

The estimates of demand and supply elasticity have been discussed in detail in Section 9.5.2.3. A separate estimate of foreign supply elasticity has not been carried out. For modeling purposes, we assume that the foreign supply elasticity is equal to the domestic supply elasticity. It is important to note that imports and domestically produced vehicles must meet the US emission standards in order to be sold in this country.

9.8.2 Snowmobile Control Costs

The emissions control costs used in the economic analysis are developed and reported in Chapter 5. In this section, we briefly recount the estimated regulatory cost per snowmobile that are used in the model. The regulatory cost per unit faced by snowmobile producers leads to a parallel shift inward of the market supply curve. As stated earlier, the compliance costs per snowmobile are projected to change in future years as different phases of the emissions control program are implemented and as the learning curve is applied (see Chapter 5 for a discussion of the learning curve). The regulatory cost per snowmobile are presented in Table 9.8-2 for the years in which they change.

Table 9.8-2
Regulatory Costs Per Snowmobile

Year	Cost Per Snowmobile	Cost Description
2006	$35	Phase 1/year 1 costs
2007	$69	Phase 1/year 2 costs
2008-2009	$65	Phase 1/year 3 and 4 costs
2010	$185	Phase 2/year 1 costs
2011	$181	Phase 2 /year 2 costs
2012	$239	Phase 3 /year 1 costs
2013	$239	Phase 3/year 2 costs
2014	$202	Phase 3/year 3 costs
2015	$196	Phase 3/year 4 costs
2016	$182	Phase 3/year 5 costs
2017-2030	$180	Phase 3/year 6 and years thereafter costs

Economic impacts are estimated based upon these costs. In the model, the baseline year quantity and price of snowmobiles are used and the per unit costs are imposed on the model to determine price, quantity, and consumer and producer surplus changes.

9.8.3 Snowmobile Economic Impact Results

The economic impacts of the regulation on the snowmobile market are estimated for each year in which the per engine regulatory costs change, assuming the baseline year 2001 price and quantity. We possess projected quantities of snowmobiles through the year 2030, however we do not have projected future year prices. Without this information, we cannot estimate the economic impacts of the future costs assuming future year quantities and prices. We instead rely upon the most current year of data to inform the model when we impose the future costs per snowmobile on producers. Using baseline year data allows us to estimate relative changes in price and quantity as opposed to absolute changes. The estimated percent changes in price and quantity, the losses in consumer and producer surplus, and total surplus loss are presented for various years in Tables 9.8-3 and 9.8-4. These results do not account for fuel cost savings that may arise from this emissions control program.

Table 9.8-3
Price and Quantity Changes for the Snowmobile Market*

Impact Measure	2006	2007	2008-2009	2010	2011	2012-2013	2014	2015	2016	2017-2030
Cost Per Unit	$35	$69	$65	$185	$181	$239	$202	$196	$182	$180
Change in Price	0.28%	0.56%	0.52%	1.49%	1.46%	1.92%	1.63%	1.58%	1.47%	1.45%
Change in Output:	-0.56%	-1.11%	-1.05%	-2.98%	-2.92%	-3.85%	-3.25%	-3.16%	-2.93%	-2.9%

*Based upon 2001baseline market conditions and impacts estimated to occur from the regulation. Assumes 2001$.

Table 9.8-4
Annual Losses in Consumer and Producer Surplus for the Snowmobile Market*

Impact Measure	Year			
	2006	**2007**	**2008-2009**	**2010**
Loss in CS** ($\$10^3$)	$2,513.9	$4,942.4	$4,657.4	$13,126.9
Loss in PS*** ($\$10^3$) Domestic Foreign	$2,380.7 $1,354.6 $1,026.1	$4,654.5 $2,648.3 $2,006.2	$4,338.9 $2,497.2 $1,891.7	$12,123.7 $6,898.1 $5,225.6
Loss in Surplus ($\$10^3$)	$4,894.6	$9,596.9	$9,049.4	$25,250.6
	2011	**2012-2013**	**2014**	**2015**
Loss in CS** ($\$10^3$)	$12,847.3	$16,883.7	$14,313.3	$13,894.9
Loss in PS*** ($\$10^3$) Domestic Foreign	$11,873.5 $6,755.8 $5,117.7	$15,448.6 $8,798.9 $6,658.7	$13,180.8 $7,499.6 $5,681.2	$12,808.8 $7,287.9 $5,520.9
Loss in Surplus ($\$10^3$)	$24,720.8	$32,332.3	$27,494.1	$26,703.7
	2016	**2017-2030**		
Loss in CS** ($\$10^3$)	$12,917.2	$12,777.4		
Loss in PS*** ($\$10^3$) Domestic Foreign	$11,936.1 $6,791.4 $5,144.7	$11,810.9 $6,720.2 $5,090.8		
Loss in Surplus ($\$10^3$)	$24,853.3	$24,588.3		

* Based upon 2001 baseline market conditions and the impact of the regulations on those market conditions. Assumes 2001$.
** CS refers to consumer surplus and is rounded to the nearest hundredths. For a description of the change in consumer surplus, see Section 9.2.2
*** PS refers to producer surplus and is rounded to the nearest hundredths. For a description of the change in producer surplus, see Section 9.2.2.

For the per snowmobile engine costs resulting from the implementation of the emissions control program, the relative increases in price over the future time period examined ranges from 0.28% to approximately 1.92% and achieve a steady state in 2017 of approximately 1.45%. The percent reductions in the market quantity of snowmobiles are initially projected to be 0.28% but increase to around 3.85% in 2012, the first year of the Phase 3 regulations. The steady state quantity reductions begin in 2017 and are approximately 2.9%. The percentage change in domestic and foreign production are the same. This is based upon the assumption that the foreign price elasticity of demand is equivalent to the domestic price elasticity of demand, and the fact that both foreign and domestic snowmobiles are subject to the emission standards. All price quantity change estimates are based upon 2001 baseline market conditions and the impact of the regulation on those baseline market conditions.

Table 9.8-4 above presents the loss in consumer surplus, the loss in producer surplus, and the total loss in surplus (equal to the sum of the changes in consumer and producer surplus) without fuel cost savings. As the table shows, the consumer surplus loss is approximately half the size of the loss in producer surplus. Producer surplus losses range from $2.4 million to $15.4 million in 2012 and reach a steady state value of $11.8 million in 2017 and beyond. The losses in consumer surplus range from $2.5 to $16.9 million and reach a steady state of $12.8 in 2017. Note that the annual surplus loss associated with the snowmobile market increases as the per snowmobile engine costs increase and declines as the per snowmobile engine costs fall. Annual loss in surplus ranges from $4.9 million to $32.3 million in 2010 and decrease to a steady state level in 2017 of $24.6 million. It is important to note that these estimates are based upon 2001 baseline conditions and the impact of the regulation on those market conditions.

9.8.4 Snowmobile Engineering Cost and Surplus Loss Comparison

This section presents a comparison of the future stream of engineering costs (excluding fuel cost savings) and surplus losses for the snowmobile market. In Table 9.8-5, we first present an interim comparison of the estimated engineering costs, holding quantity constant to the baseline year quantity. The surplus losses are estimated from the economic impact model. Because economic modeling takes into account consumer and producer behavior, the estimated loss in surplus is less than the engineering costs under a perfectly competitive market setting. In this case, the annual surplus losses are, on average, equal to 96 to 99 percent of the calculated engineering costs. It is important to note that the relationship between engineering and economic costs are based upon this comparison. It is the relationship between these costs that are assumed to actually occur in the market in future years. The cost numbers in Table 9.8-5 and 9.8-6 are not discounted.

Based upon a ratio of the loss in surplus to engineering costs, holding baseline quantity constant, a projection of the surplus loss over the future year stream is calculated from the future stream of engineering costs that appear in Chapter 7. This projection of future stream of engineering costs is based upon projected snowmobiles sales provided by ISMA and estimated per unit engineering engine modification costs. This projection of the future stream of surplus losses is compared to the future stream of engineering costs in Table 9.8-6. Note that these results are not discounted nor do they account for fuel cost savings. The relationship between engineering costs and surplus losses are determined using the market model are assumed to occur in future years. Thus the engineering costs and surplus losses shown in Table 9.8-6 are based upon forecasted sales volumes in the future, the engineering cost estimate for those sales.

Surplus losses represent the estimated value of those losses as informed by the market model, but accounting for projected sales growth in the future.

Table 9.8-5
Interim Engineering Cost and Surplus Loss Comparison for the Snowmobile Market Based on Year 2001 Baseline Market Conditions
(millions of 2001 $)

Year	Estimated Engineering Costs	Estimated Surplus Loss
2006	$4.9	$4.9
2007	$9.7	$9.6
2008 - 2009 (annually)	$9.1	$9.0
2010	$26.0	$25.2
2011	$25.5	$24.7
2012 - 2013 (annually)	$33.6	$32.3
2014	$28.4	$27.5
2015	$27.6	$26.7
2016	$25.6	$24.9
2017 - 2030 (annually)	$25.3	$24.6

9.8.5 Snowmobile Economic Impact Results with Fuel Cost Savings

In Table 9.8-7, the social costs/gains are calculated by adding the annual savings in fuel costs (presented initially in Chapter 7) to the projected annual surplus loss. These social gains are compared to the engineering costs with fuel efficiency gains. As you can see from this table, the emissions control program is expected to yield social gains rather than losses beyond the year 2014.

Table 9.8-6
Engineering Cost and Surplus Loss Comparison for the Snowmobile Market without Fuel Cost Savings Assumes Sales Growth in Future Years*
(millions of 2001 $)

Year	Estimated Engineering Costs	Estimated Surplus Loss
2006	$6.6	$6.5
2007	$13.5	$13.4
2008	$13.2	$13.0
2009	$13.5	$13.3
2010	$38.9	$37.8
2011	$38.7	$37.6
2012	$52.0	$50.0
2013	$52.7	$50.7
2014	$45.3	$43.9
2015	$44.4	$43.0
2016	$41.9	$40.6
2017	$41.7	$40.5
2018	$42.2	$41.0
2019	$42.7	$41.5
2020-2030	$43.1	$41.9

* Snowmobile sales growth provided by ISMA. Sales are not projected to grow after 2020.

Table 9.8-7
Engineering and Social Cost Comparison for the Snowmobile Market with Fuel Cost Savings - Assumes Sales Growth In Future Years*
(millions of 2001$)

Year	Estimated Engineering Costs with Fuel Cost Savings	Estimated Social Costs/Gains (Surplus Loss - Fuel Savings)*
2006	$6.2	$6.2
2007	$12.3	$12.1
2008	$10.7	$10.6
2009	$9.7	$9.6
2010	$29.4	$28.2
2011	$23.1	$21.9
2012	$26.9	$24.9
2013	$17.8	$15.8
2014	$0.4	($1.0)
2015	($10.5)	($12.0)
2016	($23.2)	($24.4)
2017	($33.2)	($34.4)
2018	($42.3)	($43.5)
2019	($50.9)	($52.1)
2020	($59.0)	($60.3)
2021	($67.0)	($68.3)
2022	($73.5)	($74.8)
2023	($78.4)	($79.6)
2024	($82.0)	($83.3)
2025	($84.5)	($85.8)
2026	($86.5)	($87.8)
2027	($88.3)	($89.5)
2028	($89.8)	($91.0)
2029	($90.9)	($92.2)
2030	($91.8)	($93.2)

* ( ) represents a negative cost (social gain). Cost estimates are based upon 2001$

9.8.6 Economic Impacts on Individual Engine Manufacturers, Snowmobile Retailers and Snowmobile Rental Firms

Insufficient data were obtained to conduct an analysis of the impact of the regulation on individual producers in the market. Thus, this analysis does not address individual producer impacts. Each snowmobile manufacturer must meet the emission standards for vehicles sold domestically. Since Yamaha and Bombardier produce their own engines, it is possible that these firms may be at a competitive advantage relative to Arctic Cat and Polaris who purchase engines from other firms. No analysis has been conducted to determine the impact of the difference in cost of production or cost of compliance for the individual firms within the industry. The EPA sought information concerning individual firm's cost of producing snowmobiles, but was unable to obtain sufficient data to conduct an analysis.

With regard to snowmobile retail and rental firms. To the extent that the price of snowmobiles increases, these firms will be impacted by the regulation The increase in market price estimated for the steady state of 1.45% does not appear sufficient to create significant impacts for these firms. In addition, most retail firms sell a variety of products, and snowmobiles are only one product in their product line. This will tend to mitigate the impact for these firms.

9.9 All-Terrain Vehicles (ATVs)

9.9.1 ATV Baseline Market Characterization

Inputs to the economic analysis are for the year 2001. Baseline characterization of the ATV market includes the domestic quantity of ATVs produced, quantity of imports, baseline market price, demand elasticity, and domestic and foreign supply elasticity measures. Table 9.9-1 provides the baseline data on the U.S. ATV market used in this analysis.

Table 9.9-1
Baseline Characterization of the U.S. ATV Market: 2001

Inputs	**Baseline Observation**
Market price ($/ATV)	$5,123.00
Market output (ATV)	880000
Domestic	874746
Foreign	5254
Elasticities	
Domestic supply (assumed)	1
Foreign supply (assumed)	1
Demand (assumed)	-2

The total quantity of ATVs sold in the U.S. was retrieved from the MIC. Trade data specific to the ATV market were unavailable. However, the International Trade Commission publishes international trade data for NAICS code 336999 - Other Transportation Equipment.

According to ITC data, imports for NAICS code 336999 account for less than 1 percent of domestic sales. The import ratio for Other Transportation Equipment is assumed to be a reasonable proxy for imports for the ATV market.

The price of ATVs used in the model is the average ATV price in 2001 provided by MIC. An average ATV market price is required to operationalize the perfectly competitive national-level market model used to examine the economic impacts of this rule on the U.S. ATV market.

The estimates of demand and supply elasticity have been discussed in detail in Section 9.5.2.4. A separate estimate of foreign supply elasticity has not been carried out. For modeling purposes, we assume that the foreign supply elasticity is equal to the domestic supply elasticity.

9.9.2 ATV Control Costs

The emission control costs used in the economic analysis are developed and reported in Chapter 5. In this section, we briefly recount the estimated regulatory cost per ATV that are used in the model. The regulatory cost per unit faced by ATV producers leads to a parallel shift inward of the market supply curve. As stated earlier, the compliance costs per ATV are projected to change in future years as different phases of the emissions control program are implemented and as the learning curve is applied (see Chapter 5 for a discussion of the learning curve). The regulatory cost per ATV are presented in Table 9.9-2 for the years in which these costs change.

Table 9.9-2
Regulatory Costs Per ATV

Year	Cost Per ATV	Cost Description
2006	$43	Phase 1/year 1 costs
2007	$82	Phase 1/year 2 costs
2008	$78	Phase 1/year 3 costs
2009	$71	Phase 1/year 4 costs
2010	$66	Phase 1/year 5 costs
2011	$57	Phase 1/year 6 costs
2012-2015	$53	Phase 1/year 7-10 costs
2016	$51	Phase 1/year 11 costs
2017-2030	$48	Phase 1/year 12-25 costs

Economic impacts are estimated based upon these costs. In the model, the baseline year quantity and price of ATVs are used and the per unit costs are imposed on the model to determine price, quantity, and consumer and producer surplus changes.

9.9.3 ATV Economic Impact Results

The economic impacts of the regulation on the ATV market are estimated for each year in which the per engine regulatory costs change, assuming the baseline year 2001 price and quantity. Estimated projected quantities of ATVs sales through the year 2030 are available, however we do not have projected future year prices. Any price projections would be subject to significant uncertainties. Without this information, we cannot estimate the economic impacts of the future costs assuming future year quantities and prices. We instead rely upon the most current year of data to inform the model when we impose the future costs per ATV on producers. Assuming annual sales and average prices are increasing for ATVs, this model approach tends to overstate potential price and quantity impacts. Using baseline year data allows us to estimate relative changes in price and quantity as opposed to absolute changes. The estimated percent changes in price and quantity, the losses in consumer and producer surplus, and total surplus loss are presented for various years in Tables 9.9-3 and 9.9-4. These results do not account for fuel cost savings that may arise from this emissions control program.

Table 9.9-3
Price and Quantity Changes for the ATV Market*

Impact Measure	Year				
	2006	**2007**	**2008**	**2009**	**2010**
Cost Per Unit	$43	$82	$78	$71	$66
Change in Market Price	0.28%	0.53%	0.51%	0.46%	0.43%
Change in Market Output	-.56%	-1.07%	-1.02%	-.92%	-.86%
Domestic	-.56%	-1.07%	-1.02%	-.92%	-.86%
Foreign	-.56%	-1.07%	-1.02%	-.92%	-.86%
	2011	**2012/2015**	**2016**	**2017/2030**	
Cost Per Unit	$57	$53	$51	$48	
Change in Market Price	0.37%	0.34%	0.33%	0.31%	
Change in Market Output	-.74%	-.69%	-0.66%	-0.62%	
Domestic	-.74%	-.69%	-0.66%	-0.62%	
Foreign	-.74%	-.69%	-0.66%	-0.62%	

*Results are the same for the years 2012 through 2015 and for 2017 through 2030. These results are not reported in separate columns to avoid repetition. Results are based on baseline year 2001 market conditions and fuel cost savings are not included.

Table 9.9-4
Annual Losses in Consumer and Producer Surplus for the ATV Market*

Impact Measure	Year				
	2006	**2007**	**2008**	**2009**	**2010**
Loss in CS** ($$10^3$)	$12,578.0	$23,925.0	$22,763.9	$20,730.5	$19,276.9
Loss in PS*** ($$10^3$)	$25,015.0	$47,336.7	$45,063.3	$41,076.0	$38,221.2
Domestic	$24,865.6	$47,054.0	$44,794.2	$40,830.8	$37,993.0
Foreign	$149.4	$282.6	$269.1	$245.2	$228.2
Loss in Surplus ($$10^3$)	$37,593.0	$71,261.7	$67,827.2	$61,806.5	$57,498.0
	2011	**2012-2015**	**2016**	**2017-2030**	
Loss in CS** ($$10^3$)	$16,658.0	$15,493.0	$14,910.4	$14,036.0	
Loss in PS*** ($$10^3$)	$33,068.0	$30,771.7	$29,622.1	$27,896.2	
Domestic	$32,870.5	$30,587.9	$29,445.3	$27,729.6	
Foreign	$197.4	$183.7	$176.9	$166.6	
Loss in Surplus ($$10^3$)	$49,726.0	$46,264.7	$44,532.5	$41,932.2	

*Results are based on baseline year 2001 market conditions and fuel cost savings are not included.
** CS refers to consumer surplus and is rounded to the nearest hundred. For a description of the change in consumer surplus, see Section 9.2.2
*** PS refers to producer surplus and is rounded to the nearest hundred. For a description of the change in producer surplus, see Section 9.2.2.

For the per ATV engine costs resulting from the implementation of the emissions control program, the relative increases in price over the future time period examined are one-half of one percent or less. The market quantity reductions are estimated to be approximately one percent or less and reach a steady state decrease of 0.62 percent in 2017. Note that the percent reduction in quantity is the same for both domestic and foreign output because it has been assumed that domestic and foreign supply have the same price elasticity.

Table 9.9-4 above presents the loss in consumer surplus, the loss in producer surplus, and the total loss in surplus (equal to the sum of the changes in consumer and producer surplus) without fuel cost savings. As the tables show, the consumer surplus loss is approximately half the size of the loss in producer surplus. Consumer surplus losses range from nearly $12.6 million in year 2006 when the rule is first implemented, it rises to $23.9 million in 2007 and falls to $14 million in 2017 and the years beyond. The losses in producer surplus range from $25 million in the first year of implementation, rising to $47.3 million in 2007 and falls to $27.9 million in 2012 and the years beyond. Note that the annual surplus loss associated with the ATV market declines as the per ATV engine costs fall starting in 2008. Loss in surplus is equal to $37.6 million in 2006, rises to 71.3 in 2007 and it falls to $42 million by 2017. The surplus estimate presented in Table 9.9-4 is based upon 2001 baseline market conditions and do not consider fuel cost savings.

9.9.4 ATV Engineering Cost and Surplus Loss Comparison

This section presents a comparison of the future stream of engineering costs (excluding fuel cost savings) and surplus losses for the ATV market. In Table 9.9-5, we first present an interim comparison of the estimated engineering costs, holding quantity constant to the baseline year quantity, with the surplus losses that were estimated from the economic impact model. Because economic modeling takes into account consumer and producer behavior, the estimated loss in surplus is less than the engineering costs under a perfectly competitive market setting. In this case, the annual surplus losses are, on average, equal to 98 to 99 percent of the calculated engineering costs. The cost numbers in Table 9.9-5 are not discounted.

Based upon a ratio of the loss in surplus to engineering costs, holding baseline quantity constant, a projection of the surplus loss over the future year stream is calculated from the future stream of engineering costs that appear in Chapter 7. This projection of the future stream of surplus losses is compared to the future stream of engineering costs in Table 9.9-6. Note that these results are not discounted nor do they account for fuel cost savings.

Table 9.9-5
Interim Engineering Cost and Surplus Loss Comparison for the ATV Based on Year 2001 Quantity (Q = 880,000 ATV)*

Year	Estimated Engineering Costs	Estimated Surplus Loss
2006	$37,840.0	$37,593.0
2007	$72,160.0	$71,261.7
2008	$68,640.0	$67,827.2
2009	$62,480.0	$61,806.5
2010	$58,080.0	$57,498.0
2011	$50,160.0	$49,726.0
2012	$46,640.0	$46,264.7
2013	$46,640.0	$46,264.7
2014	$46,640.0	$46,264.7
2015	$46,640.0	$46,264.7
2016	$44,880.0	$44,532.5
2017-2030	$42,240.0	$41,932.2

*Estimates are based on baseline year of 2001 and reflect 2001 dollars.

Table 9.9-6
Engineering Cost and Surplus Loss Comparison for the ATV Market without Fuel Cost Savings (Q = ATV projected sales for 2006 through 2030)*

Year	Estimated Engineering Costs	Estimated Surplus Loss
2006	$42,463.9	$42,186.6
2007	$81,270.6	$80,258.8
2008	$76,518.0	$75,611.8
2009	$70,287.0	$69,529.4
2010	$65,302.2	$64.681.3
2011	$56,379.5	$55,891.6
2012	$52,441.5	$52,019.5
2013	$52,441.5	$52,019.5
2014	$52,441.5	$52,019.5
2015	$52,441.5	$52,019.5
2016	$50,000.0	$49,612.0
2017-2030	$47,556.8	$47,210.3

*Estimates reflect growth in sales projected in the future and are based on 2001 dollars.

9.7.5 ATV Economic Impact Results with Fuel Cost Savings

In Table 9.9-7, the social costs/gains are calculated by adding the annual savings in fuel costs (presented initially in Chapter 7) to the projected annual surplus loss. These social gains are compared to the engineering costs with fuel efficiency gains. As you can see from this table, the emissions control program is expected to yield social gains rather than losses beginning in 2019.

Table 9.9-7
Engineering and Social Cost Comparison for the ATV Market with Fuel Cost Savings (Q = ATV projected sales for 2006 through 2030)

Year	Estimated Engineering Costs with Fuel Cost Savings	Estimated Social Costs/Gains (Surplus Loss - Fuel Savings)*
2006	$41,529.9	$41,252.7
2007	$77,878.5	$76,563.7
2008	$69,563.1	$68,657.0
2009	$59,363.1	$58,605.5
2010	$50,192.8	$49,541.9
2011	$36,888.3	$36,400.4
2012	$28,565.3	$28,143.4
2013	$24,252.7	$23,830.7
2014	$20,127.2	$19,705.2
2015	$16,223.2	$15,801.2
2016	$10,167.9	$9,780.7
2017	$4,433.1	$4,086.6
2018	$1,706.8	$1,360.2
2019	($109.4)	($456.0)
2020	($1,283.9)	($1,630.4)
2021	($2,083.2)	($2,429.8)
2022	($2,577.5)	($2,924.0)
2023	($2,951.6)	($3,298.2)
2024	($3,234.2)	($3,580.7)
2025	($3,443.4)	($3,790.0)
2026	($3,596.0)	($3,942.6)
2027	($3,707.7)	($4,054.2)
2028	($3.786.4)	($4,132.9)
2029	($3,842.7)	($4,189.3)
2030	($3,881.4)	($4,227.9)

* ( ) represents a negative cost (social gain). Cost estimates are based upon 2001$

9.10 Off-Highway Motorcycles

9.10.1 Off-Highway Motorcycle Baseline Market Characterization

Inputs to the economic analysis are for the year 2001. Baseline characterization of the off-highway motorcycle market includes the domestic quantity of off-highway motorcycles produced, quantity of imports, baseline market price, demand elasticity, and domestic and foreign supply elasticity measures. Table 9.10-1 provides the baseline data on the U.S. off-highway motorcycle market used in this analysis.

Table 9.10-1
Baseline Characterization of the U.S. Off-Highway Motorcycle Market: 2001

Inputs	Baseline Observation
Market price ($/off-highway motorcycle)	$2,253.00
Market output (off-highway motorcycle)	195250
Domestic	82463
Foreign	112787
Elasticities	
Domestic supply (estimated)	0.93
Foreign supply (assumed)	0.93
Demand (assumed)	-2

The total quantity of off-highway motorcycle sold in the U.S. was obtained from the MIC The quantity of imports of off-highway motorcycle from the International Trade Commission. According to ITC data, imports for NAICS code 336991 account for nearly 58 percent of domestic sales.

The price of off-highway motorcycles used is the average off-highway motorcycle price in 2001 provide by MIC. An average off-highway motorcycle market price is required to operationalize the perfectly competitive national-level market model used to examine the economic impacts of this rule on the U.S. off-highway motorcycle market. The import ratios for Motorcycles, Bicycles, and Parts Manufactures are assumed to be a reasonable proxy for off-highway motorcycle imports.

The estimates of demand and supply elasticity have been discussed in detail in Section 9.5.2.5. A separate estimate of foreign supply elasticity has not been carried out. For modeling purposes, we assume that the foreign supply elasticity is equal to the domestic supply elasticity.

9.10.2 Off- Highway Motorcycle Control Costs

The emissions control costs used in the economic analysis are developed and reported in Chapter 5. In this section, we briefly recount the estimated regulatory cost per off-highway motorcycle that are used to in the model. The regulatory cost per unit faced by off-highway motorcycle producers leads to a decrease in the market supply curve. As stated earlier, the compliance costs per off-highway motorcycle are projected to change in future years as different phases of the emissions control program are implemented and as the learning curve is applied (see Chapter 5 for a discussion of the learning curve). The regulatory cost per off-highway motorcycles are presented in Table 9.10-2 for the years in which they change.

Table 9.10-2
Regulatory Costs Per Off-Highway Motorcycle

Year	Cost Per Off-Highway Motorcycle	Cost Description
2006	$79	Phase 1/year 1 costs
2007	$155	Phase 1/year 2 costs
2008	$143	Phase 1/year 3 costs
2009	$128	Phase 1/year 4 costs
2010	$117	Phase 1/year 5 costs
2011	$102	Phase 1/year 6 costs
2012-2030	$99	Phase 1/year 7 costs

Economic impacts are estimated based upon these costs. In the model, the baseline year quantity and price of off-highway motorcycle are used and the per unit costs are imposed on the model to determine price, quantity, and consumer and producer surplus changes.

9.10.3 Off-Highway Motorcycles Economic Impact Results

The economic impacts of the regulation on the off-highway motorcycle market are estimated for each year in which the per engine regulatory costs change, assuming the baseline year 2001 price and quantity. Estimated projected quantities of off-highway motorcycle sales through the year 2030 are available, however we do not have projected future year prices. Without this information, we cannot estimate the economic impacts of the future costs assuming future year quantities and prices. Any price projections would be subject to significant uncertainties. We instead rely upon the most current year of data to inform the model when we impose the future costs per off-highway motorcycle on producers. Assuming annual sales and average prices are increasing for off-highway motorcycles, this model approach tends to overstate the potential price and quantity impacts. Using baseline year data allows us to estimate relative changes in price and quantity as opposed to absolute changes. The estimated percent changes in price and quantity, the losses in consumer and producer surplus, and total surplus loss are presented for various years in Tables 9.10-3. These results do not account for fuel cost savings that may arise from this emissions control program.

Table 9.10-3
Price and Quantity Changes for the Off-Highway Motorcycle Market*

Impact Measure	2006	2007	2008	2009	2010	2011	2012-2030
Cost Per Unit	$79	$155	$143	$128	$117	$102	$99
Change in Market Price	1.11%	2.18%	2.01%	1.80%	1.65%	1.44%	1.39%
Change in Market Output	-2.23%	-4.37%	-4.03%	-3.61%	-3.30%	-2.87%	-2.79%
Domestic	-2.23%	-4.37%	-4.03%	-3.61%	-3.30%	-2.87%	-2.79%
Foreign	-2.23%	-4.37%	-4.03%	-3.61%	-3.30%	-2.87%	-2.79%

*Results are the same for the years 2012 through 2030. These results are not reported in separate columns to avoid repetition. Results are based on baseline year 2001 market conditions and fuel cost savings are not included.

For the per off-highway motorcycle engine costs resulting from the implementation of the emissions control program, the relative increases in price over the future time period examined are 2.18 percent or less. By the year 2012, the relative price increase falls to approximately 1.4 percent. The percent reductions in the market quantity of off-highway motorcycles ranges from 2.23 percent to 4.37 percent, reaching a steady state of 2.79 percent in 2012. Note that the percent reduction in quantity is the same for both domestic and foreign output because it has been assumed that domestic and foreign supply have the same price elasticity.

Table 9.10-4 presents the loss in consumer surplus, the loss in producer surplus, and the total loss in surplus (equal to the sum of the changes in consumer and producer surplus) without fuel cost savings. As the table shows, the consumer surplus loss is approximately half the size of the loss in producer surplus. Consumer surplus losses range from nearly $5 million in year 2006 when the rule is first implemented, it rises to $9 million in 2007 and falls to $ 6 million in 2012 and the years beyond. The losses in producer surplus range from $10 million in the first year of implementation, rising to $19 million in 2007 and falls to $12.7 million in 2012 and the years beyond. Note that the annual surplus loss associated with the off-highway motorcycle market declines as the per off-highway motorcycle engine costs fall starting in 2008. Loss in surplus is equal to $15 million in 2006, rises to 28.7 in 2007 and it falls to $18.7 million by 2012. The surplus estimate presented in Table 9.10-4 is based upon 2001 baseline market conditions and do not consider fuel cost savings.

Table 9.10-4
Annual Losses in Consumer and
Producer Surplus for the Off-Highway Motorcycle Market*

Impact Measure	Year			
	2006	**2007**	**2008**	**2009**
Loss in CS** ($$10^3$)	$ 4,841.4	$ 9,369.1	$ 8,683.7	$ 7,789.6
Loss in PS*** ($$10^3$) Domestic Foreign	$10,177.3 $ 4,298.3 $ 5,879.0	$19,304.6 $ 8,153.2 $11,151.4	$17,906.7 $ 7,562.8 $10,343.9	$16,136.5 $ 6,815.2 $ 9,321.3
Loss in Surplus ($$10^3$)	$15,018.7	$28,700.7	$26,590.3	$23,926.1
	2010	**2011**	**2012-2030**	
Loss in CS** ($$10^3$)	$ 7,131.4	$ 6,230.5	$ 6,049.8	
Loss in PS*** ($$10^3$) Domestic Foreign	$14,822.3 $ 6,260.2 $ 8,562.1	$13,008.2 $ 5,493.9 $ 7,514.2	$12,642.3 $ 5,339.4 $ 7,302.9	
Loss in Surplus ($$10^3$)	$21,953.7	$19,238.6	$18,692.1	

*Results are based on baseline year 2001 market conditions and fuel cost savings are not included.
** CS refers to consumer surplus and is rounded to the nearest hundredths. For a description of the change in consumer surplus, see Section 9.2.2
*** PS refers to producer surplus and is rounded to the nearest hundredths. For a description of the change in producer surplus, see Section 9.2.2.

9.10.4 Off-Highway Motorcycle Engineering Cost and Surplus Loss Comparison

This section presents a comparison of the future stream of engineering costs (excluding fuel cost savings) and surplus losses for the off-highway motorcycle market. In Table 9.10-5, we first present an interim comparison of the estimated engineering costs, holding quantity constant to the baseline year quantity, with the surplus losses that were estimated from the economic impact model. Because economic modeling takes into account consumer and producer behavior, the estimated loss in surplus is less than the engineering costs under a perfectly competitive market setting. In this case, the annual surplus losses are, on average, equal to 98 to 99 percent of the calculated engineering costs. The cost numbers in this table and Table 9.10-6 are not discounted.

Based upon a ratio of the loss in surplus to engineering costs, holding baseline quantity constant, a projection of the surplus loss over the future year stream is calculated from the future stream of engineering costs that appear in Chapter 7. This projection of the future stream of surplus losses is compared to the future stream of engineering costs in Table 9.10-6. Note that these results are not discounted nor do they account for fuel cost savings.

9.10.5 Off-Highway Motorcycle Economic Impact Results with Fuel Cost Savings

In Table 9.10-7, the social costs/gains are calculated by adding the annual savings in fuel costs (presented initially in Chapter 7) to the projected annual surplus loss. These social gains are compared to the engineering costs with fuel efficiency gains. As you can see from this table, the emissions control program is expected to yield social gains rather than losses beyond the initial year of implementation. Only the initial year of implementation results in a social loss from this regulation for the off-highway motorcycle market.

Table 9.10-5
Interim Engineering Cost and Surplus Loss Comparison for the Off-Highway Motorcycle Market Based on Year 2001 Quantity
(Q = 195,250 off-highway motorcycle)

Year	Estimated Engineering Costs	Estimated Surplus Loss
2006	$15,424.8	$15,018.7
2007	$30,263.8	$28,700.7
2008	$27,920.8	$26,590.3
2009	$24,992.0	$23,926.1
2010	$22,844.3	$21,953.7
2011-2030	$19,915.5	$19,238.6

Table 9.10-6
Engineering Cost and Surplus Loss Comparison for the Off-Highway Motorcycle Market without Fuel Cost Savings
(Q = Off-Highway Motorcycle projected sales for 2006 through 2030)

Year	Estimated Engineering Costs	Estimated Surplus Loss
2006	$16,269.1	$15,840.8
2007	$32,215.0	$30,551.2
2008	$29,846.5	$28,424.3
2009	$27,127.3	$25,970.3
2010	$24,957.7	$23,984.8
2011	$22,079.4	$21,328.9
2012	$21,630.7	$20,895.5
2013	$21,847.0	$21,104.4
2014	$22,065.4	$21,315.5
2015	$22,286.1	$21,528.6
2016	$22,508.9	$21,743.9
2017	$22,734.0	$21,961.4
2018	$22,961.4	$22.181.0
2019	$23,191.0	$22,402.8
2020	$23,422.9	$22.626.8
2021	$23,657.1	$22,853.1
2022	$23,893.7	$23,081.6
2023	$24,132.6	$23,312.4
2024	$24,374.0	$23,545.6
2025	$24,617.7	$23,781.0
2026	$24,863.9	$24,018.8
2027	$25,112.5	$24,259.0
2028	$25,363.6	$24,501.6
2029	$25,617.3	$24,746.6
2030	$25,873.5	$24,994.1

Table 9.10-7
Engineering and Social Cost Comparison for the Off-Highway Motorcycle Market with Fuel Cost Savings (Q = Off-Highway Motorcycle projected sales for 2006 through 2030)

Year	Estimated Engineering Costs with Fuel Cost Savings	Estimated Social Costs/Gains (Surplus Loss - Fuel Savings)*
2006	$15,635.6	$15,207.4
2007	$30,153.2	$28,489.4
2008	$26,080.9	$24,658.7
2009	$21,459.3	$20,302.3
2010	$17,305.2	$16,332.2
2011	$12,409.1	$11,658.7
2012	$9,978.0	$9,242.8
2013	$8,293.5	$7,551.0
2014	$6,660.8	$5,910.8
2015	$5,090.2	$4,332.7
2016	$3,658.5	$2,893.5
2017	$2,529.9	$1,757.2
2018	$1,818.9	$1,039.5
2019	$1,397.3	$609.1
2020	$1,121.1	$325.0
2021	$923.2	$119.2
2022	$777.1	($35.0)
2023	$686.8	($133.4)
2024	$633.0	($195.4)
2025	$596.1	($240.6)
2026	$589.0	($256.0)
2027	$601.6	($252.0)
2028	$617.6	($244.9)
2029	$656.3	($214.4)
2030	$708.7	($170.7)

* ( ) represents a negative cost (social gain). Cost estimates are based upon 2001$

Appendix to Chapter 9: Sensitivity Analyses

This appendix presents the results from a series of sensitivity analyses completed for the recreational vehicles emissions standard. The sensitivity analyses examine how the market impacts for each vehicle category would be affected if different measures of supply and demand elasticities were used. For each vehicle category, changes in market price, quantity, and loss of consumer and producer surplus are calculated by first varying the elasticity of supply, holding the elasticity of demand fixed at the original value and then varying the elasticity of demand, holding supply elasticity fixed at its original value. The sensitivity analyses are conducted using the highest per vehicle costs over the future time stream of the regulation. We use the highest annual per vehicle costs to ensure that our sensitivity analysis examines a worst-case scenario. Analysis results are presented in comparison tables.

In order to estimate the economic impacts of the regulation on the each of the vehicle markets, we rely upon the most current year of data (either 2000 or 2001, depending on the vehicle category) to inform the model when we impose the regulatory costs per vessel on producers. Using baseline year data allows us to estimate relative changes in price and quantity as opposed to absolute changes. The results presented in these sensitivity analyses do not account for fuel cost savings that may arise from this emissions control program.

Some general observations can be made about the market impacts resulting from a regulation that affects production costs when different measures of supply and demand elasticity are used and when demand and supply are assumed to be linear. The changes in market price and quantity are smaller for an inward shift in the supply curve the more inelastic is the supply curve. The more inelastic is the demand curve, the larger is the equilibrium change in market price and the smaller is the change in market quantity from an inward shift in the supply curve.

9A.1 Sensitivity Analyses for Marine

The original estimates of supply and demand elasticity for the diesel inboard cruiser market are $\varepsilon = 1.57$ (for domestic and foreign supply) and $\eta = -1.44$, both of which are elastic. Using the highest per vessel costs of $905 which first occur in the year 2009, the market impacts on price, quantity, and surplus losses are calculated first by varying measures of supply elasticity holding demand elasticity constant and then by varying measures of demand elasticity holding supply elasticity constant. These results are presented in Tables 9A.1-1 and 9A.1-2.

In the first column of Table 9A.1-1, we reproduce the original market impacts for the year 2009 that were originally presented in Section 9.6 and compare them to the market impacts calculated when supply elasticity is assumed to be equal to $\varepsilon = 1.00$ (supply is unit elastic) and ε

= 0.50 (supply is inelastic). Demand elasticity is assumed to equal -1.44 for each of these cases. As the results show, the relative increase in market price and decrease in market output are smaller as supply becomes more inelastic. Additionally, the more inelastic is supply, the smaller is the loss in consumer surplus and larger is the loss in producer surplus. Consumer surplus loss falls to just below $2 million from approximately $4 million while producer surplus losses increases to $5.7 million from $3.6 million. While there is a change in the distribution of surplus loss across consumers and producers, there is almost no change in the overall loss in surplus with more inelastic supply. The overall surplus loss increases only by $5.6 thousand.

Table 9A.1-1
Supply Elasticity Sensitivity Analysis: Market Impacts for the Diesel Inboard Cruiser Market*

Impact Measures	**Original Results** $\xi = 1.57, \eta = -1.44$	**Unit Elastic Supply** $\xi = 1.00, \eta = -1.44$	**Inelastic Supply** $\xi = 0.50, \eta = -1.44$
Change in Market Price	0.14%	0.11%	0.07%
Change in Market Output	-0.20%	-0.16%	-0.10%
Loss in CS ($\$10^3$)**	$3,977.7	$3,126.1	$1,966.5
Loss in PS* ($\$10^3$)**	$3,641.1	$4,494.6	$5,657.9
Loss in Surplus ($\$10^3$)	$7,618.8	$7.620.7	$7,624.4

*Results are calculated using the highest per vehicle regulatory costs, which are equal to $905 and are projected to occur in the year 2009/10. Results are based on baseline year 2001 market conditions.
** CS refers to consumer surplus and is rounded to the nearest hundredths.
*** PS refers to producer surplus and is rounded to the nearest hundredths.

Table 9A.1-2 presents a comparison of the market impacts when demand elasticity is varied while holding supply elasticity constant at 1.57. We calculate the changes in market price, quantity, and surplus losses assuming η = -1.00 (demand is unit elastic) and η = -0.50 (demand is inelastic) and compare these results to the original results first presented in Section 9.6. As we assume a more inelastic demand curve, the change in market price increases while the change in quantity decreases. However, even when we assume inelastic demand, the change in market price for diesel inboard cruisers is still under one-quarter of one percent. We also can examine the change in consumer and producer surplus. In this case, consumer surplus loss increases and producer surplus loss decreases as demand becomes more inelastic. The loss in consumer surplus rises from $3.9 million to $5.9 million while producer surplus loss decreases from $3.6 million to $1.8 million. Overall surplus loss rises by approximately $9.2 thousand as demand becomes more inelastic, again a minuscule amount.

Table 9A.1-2
Demand Elasticity Sensitivity Analysis: Market Impacts for the Diesel Inboard Cruiser Market*

Impact Measures	Original Results $\xi = 1.57, \eta = -1.44$	Unit Elastic Demand $\xi = 1.57, \eta = -1.00$	Inelastic Demand $\xi = 1.57 \eta = -0.50$
Change in Market Price	0.14%	0.16%	0.20%
Change in Market Output	-0.20%	-0.16%	-0.10%
Loss in CS ($\$10^3$)**	$3,977.7	$4,659.6	$5,786.9
Loss in PS* ($\$10^3$)**	$3,641.1	$2,963.1	$1,841.1
Loss in Surplus ($\$10^3$)	$7,618.8	$7,622.7	$7,628.0

*Results are calculated using the highest per vehicle regulatory costs, which are equal to $1,552 and are projected to occur in the year 2009/10. Results are based on baseline year 2001 market conditions.
** CS refers to consumer surplus and is rounded to the nearest hundredths.
*** PS refers to producer surplus and is rounded to the nearest hundredths.

9A.2 Sensitivity Analyses for Forklifts

For the forklift market, the original economic impact analysis used an inelastic estimate of supply, equal to ε = 0.714 (for domestic and foreign supply), and an elastic estimate of demand, equal to η = -1.5. The highest per vehicle costs for the forklift market, $610, are incurred during 2004, which is the first year the regulation is implemented. Tables 9A.2-1 and 9A.2-2 present the sensitivity analyses assuming varying supply elasticities and varying demand elasticities, respectively. The results include the changes in market price, quantity, and losses in consumer and producer surplus.

Table 9A.2-1 presents the original results for the year 2004 from Section 9.7 of the analysis and then presents the market impacts assuming ε = 1.00 (supply is unit elastic) and ε = 1.50 (supply in elastic). According to these results, we find that as the supply curve becomes more elastic, the changes in both market price and quantity are larger. Assuming elastic supply, we find that the increase in market price is equal to 1.16 percent and the decrease in market quantity is equal to -1.73 percent. These market impacts, though larger than those we find when supply is assumed to be inelastic, are not significant. We also examine the changes in consumer and producer surplus to find that as supply becomes more elastic, the loss in consumer surplus increases from $12.7 million to $19.7 million and the loss in producer surplus falls from $26.4 million to $19.3 million. Along with this redistribution of surplus loss is a reduction in the overall loss in surplus as supply is assumed to be elastic. The overall loss in surplus originally was equal to \$39.1 million but falls to just under \$39 million when $\varepsilon = 1.50$.

Table 9A.2-1
Supply Elasticity Sensitivity Analysis: Market Impacts for the Forklift Market*

Impact Measures	Original Results $\xi = 0.714, \eta = -1.50$	Unit Elastic Supply $\xi = 1.00, \eta = -1.50$	Elastic Supply $\xi = 1.50, \eta = -1.50$
Change in Market Price	0.75%	0.92%	1.16%
Change in Market Output	-1.12%	-1.39%	-1.73%
Loss in CS (10^3)**	\$12,715.3	\$15,750.0	\$19,653.1
Loss in PS* (10^3)**	\$26,412.4	\$23,294.9	\$19,309.3
Loss in Surplus (10^3)	\$39,127.7	\$29,044.9	\$38,962.4

*Results are calculated using the highest per vehicle regulatory costs, which are projected to occur in the year 2004 and are equal to \$610 per forklift. Results are based on baseline year 2000 market conditions.
** CS refers to consumer surplus and is rounded to the nearest hundredths.
*** PS refers to producer surplus and is rounded to the nearest hundredths.

In the next table, demand elasticity is varied holding supply elasticity constant. The original results were generated assuming $\varepsilon = 0.714$ and $\eta = -1.5$. To conduct the sensitivity analysis, we estimated the market impacts when demand elasticity was equal to -1 (unit elastic) and also when it was equal to -0.5 (inelastic). The results in Table 9A.2-2 show that as demand becomes more inelastic, the change in market price increases while the change in quantity decreases. The largest change in market price is approximately 1.4 percent, which is still small in scale. An examination of the surplus measures shows that the loss in consumer surplus increases and the loss in producer surplus decreases as demand is more inelastic. Originally, consumer surplus loss was equal to \$12.7 million and producer surplus was equal to \$26.4 million. For the inelastic demand case, consumer surplus loss increases to \$23.4 million while the loss in producer surplus falls to \$16.2 million. Like the diesel marine vessel case, the overall change in the total loss in surplus is negligible, approximately \$3 thousand.

A sensitivity analysis for forklifts was also conducted using the estimated elasticity of demand discussed in Section 9.5 of Chapter 9. The demand elasticity estimated is equal to -5.76, a rather large estimate. Table 9A.2-3 presents a comparison of the original market impacts originally presented in Chapter 9 with the market impacts when $\varepsilon = 0.714$ and $\eta = -5.76$. From this sensitivity analysis, EPA finds that the relative increase in market price is one-quarter of one percent while the decrease in market output is approximately one and one-half percent. The price increase is smaller relative to the original results because of the extremely elastic demand measure. Overall, these market impacts are not very different from the original results.

What does differ a great deal is the distribution of the loss in welfare. Originally, the loss in producer surplus was approximately two times the size of the loss in consumer surplus. When the elasticity of demand is equal to -5.76, however, virtually all of the loss in economic welfare is incurred by producers. Almost 90 percent of the loss in welfare is borne by producers while 10 percent is borne by consumers.

Table 9A.2-2
Demand Elasticity Sensitivity Analysis: Market Impacts for the Forklift Market*

Impact Measures	**Original Results** $\xi = 0.714, \eta = -1.50$	**Unit Elastic Demand** $\xi = 0.714, \eta = -1.00$	**Inelastic Demand** $\xi = 0.714, \eta = -0.50$
Change in Market Price	0.75%	0.96%	1.36%
Change in Market Output	-1.12%	-0.96%	-0.68%
Loss in CS ($\$10^3$)**	$12,715.3	$16,437.4	$23,240.4
Loss in PS* ($\$10^3$)**	$26,412.4	$22,798.8	$16,163.7
Loss in Surplus ($\$10^3$)	$39,127.7	$39,236.2	$39,404.1

*Results are calculated using the highest per vehicle regulatory costs, which are projected to occur in the year 2004 and are equal to $610 per forklift. Results are based on baseline year 2000 market conditions.
** CS refers to consumer surplus and is rounded to the nearest hundredths.
*** PS refers to producer surplus and is rounded to the nearest hundredths.

Table 9A.2-3
Alternative Demand Elasticity Sensitivity Analysis: Market Impacts for the Forklift Market*

Impact Measures	Original Results $\xi = 0.714, \eta = -1.50$	Alternative Elastic Demand $\xi = 0.714, \eta = -5.76$
Change in Market Price	0.75%	0.25%
Change in Market Output	-1.12%	-1.47%
Loss in CS ($\$10^3$)**	\$12,715.3	\$4,340.8
Loss in PS* ($\$10^3$)**	\$26,412.4	\$34,499.8
Loss in Surplus ($\$10^3$)	\$39,127.7	\$38,840.6

*Results are calculated using the highest per vehicle regulatory costs, which are projected to occur in the year 2004 and are equal to $610 per forklift. Results are based on baseline year 2000 market conditions.
** CS refers to consumer surplus and is rounded to the nearest hundredths.
*** PS refers to producer surplus and is rounded to the nearest hundredths.

9A.3 Sensitivity Analyses for Snowmobiles

For the snowmobile market, the original economic impact analysis used an elastic estimate of supply, equal to $\varepsilon = 2.1$ (for domestic and foreign supply), and an elastic estimate of demand, equal to $\eta = -2.0$. The steady state per vehicle engine modification costs resulting from the regulation for the snowmobiles market of $180, are incurred during 2017 through 2030. This per unit vehicle cost of emission controls is based upon 2001 price levels, Phase 3 regulatory requirements, and incorporates the impact of the learning curve for the engine modification costs. The EPA contends these per unit costs represent those the snowmobile manufacturers will experience on an ongoing basis due to this regulation. Tables 9A.3-1 and 9A.3-2 present the sensitivity analyses assuming varying supply elasticities and varying demand elasticities, respectively. The results include the changes in market price, quantity, and losses in consumer and producer surplus. All estimates are based upon the 2001 baseline market conditions.

Table 9A.3-1 presents the original results for the year 2017-2030 from Section 9.8 of the analysis and then presents the market impacts assuming $\varepsilon = 2.6$ (supply is more elastic) and $\varepsilon = 1.60$ (supply is less elastic). According to these results, we find that as the supply curve becomes more elastic, the changes in both market price and quantity are somewhat larger. These market impacts, though larger than those we find when supply is assumed to be 2.1, are not significantly different. We also examine the changes in consumer and producer surplus to find that as supply becomes more elastic, the loss in consumer surplus increases from $12.8 million to $14.1 million and the loss in producer surplus falls from $11.8 million to $10.5 million. Along with this redistribution of surplus loss is a reduction in the overall loss in surplus as supply is assumed to be more elastic. When supply is assumed to be less elastic, price and quantity impacts decrease. With less elastic supply producers bear more of the cost of the regulation. As illustrated by this sensitivity analysis, price and quantity market impacts do not change substantially with reasonable changes in the supply elasticity measures. As supply become less elastic producers bear more of the cost of the regulation.

Table 9A.3-1
Supply Elasticity Sensitivity Analysis: Market Impacts for the Snowmobile Market*

Impact Measures	**Original Results** $\xi = 2.1, \eta = -2.0$	**More Elastic Supply** $\xi = 2.6, \eta = -2.0$	**Less Elastic Supply** $\xi = 1.60, \eta = -.2.0$
Change in Market Price	1.45%	1.60%	1.26%
Change in Market Output	-2.90%	-3.20%	-2.52%
Loss in CS ($\$10^3$)	$12,777.4	$14,078.6	$11,108.8
Loss in PS* ($\$10^3$)	$11,810.9	$10,447.6	$13,532.7
Loss in Surplus ($\$10^3$)	$24,588.3	$24,556.2	$24,641.0

*Results are calculated using the steady-state per vehicle regulatory costs, which are projected to occur in the year 2015 through 2030 and are equal to $178 per snowmobile. Results are based on baseline year 2001 market conditions.
** CS refers to consumer surplus and is rounded to the nearest hundred.
*** PS refers to producer surplus and is rounded to the nearest hundred.

In the next table, demand elasticity is varied holding supply elasticity constant. The original results were generated assuming ε = 2.1 and η = -2.0. To conduct the sensitivity analysis, we estimated the market impacts when demand elasticity was equal to -2.5 (more elastic) and also when it was equal to -1.5 (less elastic). The results in Table 9A.3-2 show that as demand becomes more elastic, the change in market price decreases while the change in quantity increases. With more elastic demand, producers bear more of the burden of the regulation, while consumers bear less. The overall surplus loss declines slightly. With less elastic demand, the price change increases and quantity change decreases somewhat. Consumers pay a larger share of the cost of the regulation with less elastic demand and producers a smaller share. The surplus losses associated with the regulation increase slightly.

On August 2, 2002, National Economic Research Associates (NERA) provided the EPA with the document *Economic Assessments of Alternative Emission Standards for Snowmobile Engines* on behalf of ISMA. In this report, an estimate of the price elasticity of demand for snowmobiles is presented. The EPA does not accept the validity of this elasticity estimate for a number of reasons (see September 11, 2002 memorandum from Chris Lieske and Linda Chappell to Docket A-2000-01, Document IV-B-45). In an effort to provide additional information to quantify the market impacts of a more elastic price elasticity of demand, market impacts for a price elasticity of demand estimate of -4.63 are presented in Table 9A.3-2. As shown in the third column of this table, projected price increases are smaller and market quantity decreases are somewhat larger assuming a price elasticity of demand estimate of -4.63. In addition, producers bear a greater portion of the burden of the regulation assuming the more elastic price elasticity of demand.

$$\xi = 2.1, \eta = -4.63$$

Table 9A.3-2
Demand Elasticity Sensitivity Analysis: Market Impacts for the Snowmobile Market*

Impact Measures	**Original Results** $\xi = 2.1, \eta = -2.0$	**More Elastic Demand** $\xi = 2.1, \eta = -2.5$	**More Elastic Demand**	**Less Elastic Demand** $\xi = 2.1, \eta = -1.5$
Change in Market Price	1.45%	1.29%	0.88%	1.65%
Change in Market Output	-2.90%	-3.23%	-1.09%	-2.48%
Loss in CS ($$10^3$)**	$12,777.4	$11,369.4	$7,737.1	$14,583.2
Loss in PS* ($$10^3$)**	$11,810.9	$13,090.6	$16,364.5	$10,155.4
Loss in Surplus ($$10^3$)	$24,588.3	$24,460.0	$24,083.6	$24,738.6

*Results are calculated using the steady-state per vehicle regulatory costs, which are projected to occur in the year 2015 through 2030 and are equal to $$178 per snowmobile. Results are based on baseline year 2001 market conditions.
** CS refers to consumer surplus and is rounded to the nearest hundred.
*** PS refers to producer surplus and is rounded to the nearest hundred.

In general, the sensitivity analysis indicates that market impacts are not particularly sensitive to reasonable changes in the price elasticity of supply and demand. However, this sensitivity analysis does indicate that the surplus losses borne by consumers and producers are impacted by these estimates. Less elastic supply leads to the producer bearing a greater percentage of the losses due to the regulation. Less elastic demand leads to consumers bearing more of the cost of the regulation.

9A.4 Sensitivity Analyses for ATV

For the ATV market, the original economic impact analysis used an original estimate of supply, equal to ε = 1.0 (for domestic and foreign supply), and an elastic estimate of demand, equal to η = -2.0. The steady state per vehicle costs for the ATV market, $48, are incurred during 2012 through 2030. Tables 9A.4-1 and 9A.4-2 present the sensitivity analyses assuming varying supply elasticities and varying demand elasticities, respectively. The results include the changes in market price, quantity, and losses in consumer and producer surplus.

Table 9A.4-1 presents the original results for the year 2012 from Section 9.9 of the analysis and then presents the market impacts assuming ε = 1.50 (supply is more elastic) and ε = .50 (supply in elastic). Assuming the more elastic supply of ε = 1.50, we find that the increase in market price is equal to 0.40 percent and the decrease in market quantity is equal to -0.80 percent. Assuming the in elastic supply of ε = 0.50, we find that the increase in market price is equal to 0.19 percent and the decrease in market quantity is equal to -0.37 percent. We also examine the changes in consumer and producer surplus to find that as supply becomes more elastic, the loss in consumer surplus increases were $18.0 million and $8.4 million and the loss in producer surplus are $23.8 million and $33.4 million, respectively . The overall loss in surplus originally was equal to $41.9 million and $42.0 million, respectively.

Table 9A.4-1
Supply Elasticity Sensitivity Analysis: Market Impacts for the ATV Market*

Impact Measures	**Original Results** $\xi = 1.0, \eta = -2.0$	**More Elastic Supply** $\xi = 1.5, \eta = -2.0$	**InElastic Supply**
Change in Market Price	0.31%	0.40%	0.19%
Change in Market Output	-0.62%	-0.80%	-0.37%
Loss in CS (10^3)**	$14,036.0	$18,030.2	$8,432.2
Loss in PS* (10^3)**	$27,896.2	$23,846.4	$33,401.4
Loss in Surplus (10^3)	$41,932.2	$41,876.5	$42,034.2

*Results are calculated using the steady state per vehicle regulatory costs, which are projected to occur in the year 2012 through 2030 and are equal to $48 per ATV. Results are based on baseline year 2001 market conditions.
** CS refers to consumer surplus and is rounded to the nearest hundredths.
*** PS refers to producer surplus and is rounded to the nearest hundredths.

In the next table, demand elasticity is varied holding supply elasticity constant. The original results were generated assuming ε = 1.0 and η = -2.0. To conduct the sensitivity analysis, we estimated the market impacts when demand elasticity was equal to -2.5 (more elastic) and also when it was equal to -1.5 (less elastic). The results in Table 9A.4-2 show that as demand becomes more inelastic, the change in market price increases while the change in quantity decreases. An examination of the surplus measures shows that the loss in consumer surplus increases and the loss in producer surplus decreases as demand is more inelastic. Originally, consumer surplus loss was equal to $14.0 million and producer surplus was equal to $27.9 million. For the more elastic demand case, consumer surplus loss falls to $12.0 million while the loss in producer surplus increase to $29.9 million. The overall change in the total loss in surplus is negligible, approximately $20.

Table 9A.4-2
Demand Elasticity Sensitivity Analysis: Market Impacts for the ATV Market*

Impact Measures	Original Results a	More Elastic Demand _2	Inelastic Demand x = 1.0, h = -1.5
Change in Market Price	0.31%	0.27%	0.37%
Change in Market Output	-0.62%	-0.67%	-0.56%
Loss in CS ($10^3)**	$14,036.0	$12,028.2	$16,848.5
Loss in PS* ($10^3)**	$27,896.2	$29,868.6	$25,130.3
Loss in Surplus ($10^3)	$41,932.2	$41,876.7	$41,978.8

*Results are calculated using the steady state per vehicle regulatory costs, which are projected to occur in the year 2012 through 2030 and are equal to $48 per ATV. Results are based on baseline year 2001 market conditions.
** CS refers to consumer surplus and is rounded to the nearest hundredths.
*** PS refers to producer surplus and is rounded to the nearest hundredths.

9A.5 Sensitivity Analyses for Off-Highway Motorcycle

For the off-highway motorcycle market, the original economic impact analysis used an original estimate of supply, equal to ε = 0.93 (for domestic and foreign supply), and an elastic estimate of demand, equal to η = -2.0. The steady state per vehicle costs for the off-highway motorcycle market, $99, are incurred during 2012 through 2030. Tables 9A.5-1 and 9A.5-2 present the sensitivity analyses assuming varying supply elasticities and varying demand elasticities, respectively. The results include the changes in market price, quantity, and losses in consumer and producer surplus.

Table 9A.5-1 presents the original results for the year 2012 from Section 9.10 of the analysis and then presents the market impacts assuming ε = 1.50 (supply is more elastic) and ε = .50 (supply in elastic). Assuming the more elastic supply of ε = 1.50, we find that the increase in market price is equal to 1.88 percent and the decrease in market quantity is equal to -3.77 percent. Assuming the in elastic supply of ε = 0.50, we find that the increase in market price is equal to 0.88 percent and the decrease in market quantity is equal to -1.76 percent. We also examine the changes in consumer and producer surplus to find that as supply becomes more elastic, the loss in consumer surplus increases were $8.1 million and $3.8 million and the loss in producer surplus are $10.4 million and $15.1 million, respectively . The overall loss in surplus originally was equal to $18.6 million and $18.9 million, respectively.

Table 9A.5-1
Supply Elasticity Sensitivity Analysis: Market Impacts for the Off-highway Motorcycle Market*

Impact Measures	**Original Results** $x = 0.93, h = -2.0$	**More Elastic Supply** $x = 1.5, h = -2.0$	**InElastic Supply** $x = .50, h = -2.0$
Change in Market Price	1.39%	1.88%	.88%
Change in Market Output	-2.79%	-3.77%	-1.76%
Loss in CS (10^3)**	$6,049.8	$8,128.2	$3,832.0
Loss in PS* (10^3)**	$12,642.3	$10,421.5	$15,056.1
Loss in Surplus (10^3)	$5,339.42	$18,549.7	$18,888.1

*Results are calculated using the steady state per vehicle regulatory costs, which are projected to occur in the year 2012 through 2030 and are equal to $99 per off-highway motorcycle. Results are based on baseline year 2001 market conditions.
** CS refers to consumer surplus and is rounded to the nearest hundredths.
*** PS refers to producer surplus and is rounded to the nearest hundredths.

In the next table, demand elasticity is varied holding supply elasticity constant. The original results were generated assuming ε = 0.93 and η = -2.0. To conduct the sensitivity analysis, we estimated the market impacts when demand elasticity was equal to -2.5 (more elastic) and also when it was equal to -1.5 (less elastic). The results in Table 9A.2-5 show that as demand becomes more inelastic, the change in market price increases while the change in quantity decreases. An examination of the surplus measures shows that the loss in consumer surplus increases and the loss in producer surplus decreases as demand is more inelastic. Originally, consumer surplus loss was equal to $6.1 million and producer surplus was equal to

$12.7 million. For the more elastic demand case, consumer surplus loss falls to $5.6 million while the loss in producer surplus increase to $13.5 million. The overall change in the total loss in surplus is negligible, approximately $10.

Table 9A.5-2
Demand Elasticity Sensitivity Analysis: Market Impacts for the Off-highway Motorcycle Market*

Impact Measures	**Original Results** $\xi = 0.93, \eta = -2.0$	**More Elastic Demand** $\xi = 0.93, \eta = -2.5$	**Inelastic Demand** $\xi = 0.93, \eta = -1.5$
Change in Market Price	1.39%	1.19%	1.68%
Change in Market Output	-2.79%	-2.98%	-2.52%
Loss in CS ($\$10^3$)**	$6,049.8	$5,163.0	$7,304.5
Loss in PS* ($\$10^3$)**	$12,649.3	$13,459.3	$11,480.5
Loss in Surplus ($\$10^3$)	$18,692.1	$18,622.2	$18,785.0

*Results are calculated using the steady state per vehicle regulatory costs, which are projected to occur in the year 2012 through 2030 and are equal to $99 per off-highway motorcycle. Results are based on baseline year 2001 market conditions.
** CS refers to consumer surplus and is rounded to the nearest hundredths.
*** PS refers to producer surplus and is rounded to the nearest hundredths.

Chapter 9 References

1. International Snowmobile Manufacturing Association. www.snowmobile.org. 2002. Docket A-2000-01, Document IV-A-140.

2. U.S. EPA. 1999. OAQPS Economic Analysis Resource Document. Office of Air Quality Planning and Standards, Air Quality Strategies and Standards Division, Innovative Strategies and Economics Group. April. Docket A-2000-01, Document IV-A-71.

3. National Park Service *News Release*. Final Snowmobile Regulations For Yellowstone and Grand Teton National Parks Published in Federal Register. January 23, 2001. Docket A-2000-01, Document No. IV-A-119.

4. See Letter from Linc Wehrly to Docket, titled "News Articles for Yamaha 4-Stroke Snowmobile." Docket A-2000-01. Docket A-2000-01, Document IV-B-25.

5. Internet Search. www.yamaha-motors.com. August 2002. Docket A-2000-01, Document Nos. IV-A-111, IV-A-121, and IV-A-139.

6. Production data were taken from OELINK Database owned by Power Systems Research.

7. Internet Search. www.yamaha-motors.com. June 2002. Docket A-2000-01, Document Nos. IV-A-111, IV-A-121, and IV-A-139.

8. Estimated based upon submission of data by ISMA manufacturers and Southwest Research Institute. Carroll (1999), White et.al. (1997), Hare and Springer 1974, White and Wright (1998). These documents can be found in Docket A-2000-01, Documents II-B-19, II-D-15, IV-A-142, II-A-50, and II-D-05.

9. Estimated based upon submission of data by ISMA manufacturers and Southwest Research Institute. Carroll (1999), White et.al. (1997), Hare and Springer 1974, White and Wright (1998). These documents can be found in Docket A-2000-01, Documents II-B-19, II-D-15, IV-A-142, II-A-50, and II-D-05.

10. Internet Search. www.polarisindustries.com/product/default.asp?contentid=sno June 2002. Docket A-2000-01, Document Nos. IV-A-111, IV-A-120, and IV-A-139.

11. Internet Search. www.yamaha-motors.com. June 2002 Docket A-2000-01, Document Nos. IV-A-111, IV-A-120, and IV-A-139.

12. Internet Search. www.yamaha-motors.com. June 2002. Docket A-2000-01, Document Nos. IV-A-111, IV-A-120, and IV-A-139.

13. Internet Search. http://www.arctic-cat.com/snowmobiles/index.asp June 2002. Docket A-2000-01, Document Nos. IV-A-111, IV-A-120, and IV-A-139.

14. Internet Search. www.polarisindustries.com/product/default.asp?contentid=sno, www.yamaha-motors.com., www.yamaha-motors.com., http://www.arctic-cat.com/snowmobiles/index.asp June 2002. Docket A-2000-01, Document Nos. IV-A-111, IV-A-120, IV-A-121, and IV-A-139.

15. Internet Search. www.polarisindustries.com/product/default.asp?contentid=sno, www.yamaha-motors.com., www.yamaha-motors.com., http://www.arctic-cat.com/snowmobiles/index.asp June 2002. Docket A-2000-01, Document Nos. IV-A-111, IV-A-120, IV-A-121, and IV-A-139

16. Internet Search. www.polarisindustries.com/product/default.asp?contentid=sno, www.yamaha-motors.com., www.yamaha-motors.com., http://www.arctic-cat.com/snowmobiles/index.asp June 2002. Docket A-2000-01, Document Nos. IV-A-111, IV-A-120, IV-A-121, and IV-A-139.

17. Internet Search. www.polarisindustries.com/product/default.asp?contentid=sno, www.yamaha-motors.com., www.yamaha-motors.com., http://www.arctic-cat.com/snowmobiles/index.asp June 2002. Docket A-2000-01, Document Nos. IV-A-111, IV-A-120, IV-A-121, and IV-A-139.

18. Raboy, David G. 1987. Results of an Economic Analysis of Proposed Excise Taxes on Boats mimeo. Washington DC: Patton, Boggs, and Blow. Prepared for the National Marine Manufacturing Association. Docket A-2000-01, Document IV-A-129.

19. National Bureau of Economic Research and U.S. Census Bureau, Center for Economic Research. 2002. NBER-CES Manufacturing Industry Database, 1958 - 1996. http://www.nber.org/nberces/nbprod96.htm Docket A-2000-01, Document IV-A-48 and IV-A-190.

20. U.S. Department of Commerce. 2001. 1999 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-58

21. Bureau of Economic Analysis. 2002. Survey of Current Business - D. Domestic Perspectives. January. http://www.bea.doc.gov/bea/ARTICLES/2002/01January/D-Pages/0102DpgD.pdf. Docket A-2000-01, Document IV-A-55.

22. Bureau of Economic Analysis.1999. Survey of Current Business - D. Domestic Perspectives. December. http://www.bea.doc.gov/bea/ARTICLES/NATIONAL/NIPAREL/1999/1299dpgd.pdf. Docket

A-2000-01, Document IV-A-56.

23. Bureau of Economic Analysis. 2002. Shipments of Manufacturing Industries. http://www.bea.doc.gov/bea/dn2/gpo.htm Docket A-2000-01, Document IV-A-44 and IV-A-191.

24. Bureau of Economic Analysis. National Income and Product Accounts Tables. Table 7.1 - Quantity and Price Indices for GDP. http://www.bea.gov/bea/dn/nipaweb/SelectTable.asp?Selected=Y#s7 Docket A-2000-01, Document IV-A-192.

25. Pindyck, Robert S. and Daniel L. Rubinfeld. Econometric Models and Economic Forecasts, 2nd edition. McGraw Hill Publishing. 1981. Pages174-201.

26. Industrial Truck Association. 2002. Membership Handbook. http://www.indtrk.com/ Copies of relevant pages can be found in Docket A-2000-01, Document IV-A-188.

27. National Bureau of Economic Research and U.S. Census Bureau, Center for Economic Research. 2002. NBER-CES Manufacturing Industry Database, 1958 - 1996. http://www.nber.org/nberces/nbprod96.htm Docket A-2000-01, Document IV-A-48 and IV-A-190.

28. U.S. Department of Commerce. 2001. 1999 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-58.

29. Bureau of Economic Analysis. 2002. Survey of Current Business - D. Domestic Perspectives. January. http://www.bea.doc.gov/bea/ARTICLES/2002/01January/D-Pages/0102DpgD.pdf Docket A-2000-01, Document IV-A-55

30. Bureau of Economic Analysis. 1999. Survey of Current Business - D. Domestic Perspectives. December. http://www.bea.doc.gov/bea/ARTICLES/NATIONAL/NIPAREL/1999/1299dpgd.pdf Docket A-2000-01, Document IV-A-56.

31. Bureau of Economic Analysis. 2002. Shipments of Manufacturing Industries. http://www.bea.doc.gov/bea/dn2/gpo.htm Docket A-2000-01, Document IV-A-44 and IV-A-191.

32. Bureau of Economic Analysis. National Income and Product Accounts Tables. Table 7.1 - Quantity and Price Indices for GDP. http://www.bea.gov/bea/dn/nipaweb/SelectTable.asp?Selected=Y#s7 Docket A-2000-01, Document IV-A-192.

33. National Bureau of Economic Research and U.S. Census Bureau, Center for Economic Research. 2002. NBER-CES Manufacturing Industry Database, 1958 - 1996. http://www.nber.org/nberces/nbprod96.htm Docket A-2000-01, Document IV-A-48 and IV-A-190.

34. U.S. Department of Commerce. 2001. 1999 Annual Survey of Manufactures - Statistics for Industry Groups and Industries. Washington, DC: Government Printing Office. Docket A-2000-01, Document IV-A-58.

35. Bureau of Economic Analysis. 2002. Survey of Current Business - D. Domestic Perspectives. January. http://www.bea.doc.gov/bea/ARTICLES/2002/01January/D-Pages/0102DpgD.pdf Docket A-2000-01, Document IV-A-55.

36. Bureau of Economic Analysis. 1999. Survey of Current Business - D. Domestic Perspectives. December. http://www.bea.doc.gov/bea/ARTICLES/NATIONAL/NIPAREL/1999/1299dpgd.pdf Docket A-2000-01, Document IV-A-56.

37. Bureau of Economic Analysis. 2002. Shipments of Manufacturing Industries. http://www.bea.doc.gov/bea/dn2/gpo.htm Docket A-2000-01, Document IV-A-44 and IV-A-191.

38. Bureau of Economic Analysis. National Income and Product Accounts Tables. Table 7.1 - Quantity and Price Indices for GDP. http://www.bea.gov/bea/dn/nipaweb/SelectTable.asp?Selected=Y#s7 Docket A-2000-01, Document IV-A-192.

39. Raboy, David G. 1987. Results of an Economic Analysis of Proposed Excise Taxes on Boats mimeo. Washington DC: Patton, Boggs, and Blow. Prepared for the National Marine Manufacturing Association. Docket A-2000-01, Document IV-A-129.

40. National Bureau of Economic Research and U.S. Census Bureau, Center for Economic Research. 2002 NBER-CES Manufacturing Industry Database, 1958 - 1996. Docket A-2000-01, Document IV-A-48 and IV-A-190.

41. U. S. Department of Commerce. 2001. 1999 Annual Survey of Manufacturers - Statistics for Industry Groups and Industries. Washington, DC Government Printing Office. Docket A-2000-01, Document IV-A-58.

42. U. S. Department of Commerce. 2001. 2000 Annual Survey of Manufacturers - Statistics for Industry Groups and Industries. Washington, DC Government Printing Office.

43. Bureau of Economic Analysis. 2002. Shipments of Manufacturing Industries. http://bea.gov/bea/dn2/gpo.htm Docket A-2000-01, Document IV-A-44 and IV-A-191.

44. Bureau of Economic Analysis. 2002. Survey of Current Business -D Domestic Perspectives. January. http://www.bea.doc/bea/ARTICLES/2002/01January/D-Pages/0102Dpg.pdf Docket A-2000-01, Document IV-A-55.

45. Bureau of Economic Analysis. 1999. Survey of Current Business -D Domestic Perspectives. December. http://www.bea.doc/bea/ARTICLES/NATIONAL/NIPAREL/19991299dpgd.pdf Docket A-2000-01, Document IV-A-56.

46. International Snowmobile Manufacturers Association. www.snowmobile.org. June 2002.

47. US Census Bureau, Historical Income Tables – Households, Table H-6, Regions – Households (All Races) by Median and Mean Income, 1975-2000. A copy of this information can be found in Docket A-2000-01, Document VI-A-203.

48. Raboy, David G. 1987. Results of an Economic Analysis of Proposed Excise Taxes on Boats mimeo. Washington DC: Patton, Boggs, and Blow. Prepared for the National Marine Manufacturing Association. Docket A-2000-01, Document IV-A-129.

49. Raboy, David G. 1987. Results of an Economic Analysis of Proposed Excise Taxes on Boats mimeo. Washington DC: Patton, Boggs, and Blow. Prepared for the National Marine Manufacturing Association. Docket A-2000-01, Document IV-A-129.

50. National Bureau of Economic Research and U.S. Census Bureau, Center for Economic Research. 2002 NBER-CES Manufacturing Industry Database, 1958 - 1996. Docket A-2000-01, Document IV-A-48 and IV-A-190.

51. U. S. Department of Commerce. 2001. 1999 Annual Survey of Manufacturers - Statistics for Industry Groups and Industries. Washington, DC Government Printing Office. Docket A-2000-01, Document IV-A-58.

52. Bureau of Economic Analysis. 2002. Shipments of Manufacturing Industries. http://bea.gov/bea/dn2/gpo.htm Docket A-2000-01, Document IV-A-44 and IV-A-191.

53. Bureau of Economic Analysis. 2002. Survey of Current Business -D Domestic Perspectives. January. http://www.bea.doc/bea/ARTICLES/2002/01January/D-Pages/0102Dpg.pdf Docket A-2000-01, Document IV-A-55.

54. Bureau of Economic Analysis. 2002. Shipments of Manufacturing Industries. http://bea.gov/bea/dn2/gpo.htm Docket A-2000-01, Document IV-A-44 and IV-A-191.

55. Bureau of Economic Analysis. 1999. Survey of Current Business -D Domestic Perspectives. December. http://www.bea.doc/bea/ARTICLES/NATIONAL/NIPAREL/19991299dpgd.pdf Docket A-2000-01, Document IV-A-56.

56. Motorcycle Industry Council, Inc. 2002. Docket A-2000-01, Document No. IV-A-138.

57. US Census Bureau, Historical Income Tables – Households, Table H-6, Regions – Households (All Races) by Median and Mean Income, 1975-2000. A copy of this information can be found in Docket A-2000-01, Document VI-A-203.

58. National Marine Manufacturing Association. *U.S. Recreational Boating Domestic Shipment Statistics, 1970 - 1998*. http://63.236.237.146/facts/history.pdf Docket A-2000-01, Document IV-A-49.

59. National Marine Manufacturing Association. Boating 2001 - Facts and Figures at a Glance. http://www.nmma.org/facts/boatingstats/2001/ Docket A-2000-01, Document IV-A-50.

60. Teleconference with John McKnight of the National Marine Manufacturers Association on April 15, 2002.

61. Boating Industry. 1996. The Boating Business, 1995 Annual Industry Review. January. Docket A-2000-01, Document IV-A-43.

62. National Marine Manufacturing Association. 2002. Economic Impact Analysis of the Diesel Engine Rule on the U.S. Boat Market. Table 4 - Product Analysis: Inboard Boats, Imports. Docket A-2000-01, Document IV-A-53.

63. National Marine Manufacturing Association. 2002. Economic Impact Analysis of the Diesel Engine Rule on the U.S. Boat Market. Docket A-2000-01, Document IV-A-53.

64. ISMA Snowmobile Statistics www.snowmobile.org. June 2002.

65. Production data were taken from OELINK Database owned by Power Systems Research.

Chapter 10: Benefit-Cost Analysis

10.1 Introduction

This chapter contains EPA's analysis of the economic benefits of the Large SI/Recreational Vehicle rule. The analysis presented here attempts to answer three questions

- What are the physical health and welfare effects of changes in ambient air quality resulting from reductions in nitrogen oxides (NOx), hydrocarbons (HC) (including air toxics), carbon monoxide (CO), and particulate matter (PM) emissions?
- What is the value placed on these emission reductions by U.S. citizens as a whole?
- How do these estimated benefits compare to the estimated costs associated with this rule?

In the benefits analysis, we calculate a limited set of PM-related health benefits (our base-case estimate). In this part of the analysis, we estimate nationwide PM health effects benefits associated with reduction of Nox and direct PM emissions from Large SI only. Reductions related to ATVs, OHMs, snowmobiles and recreational marine diesel are not quantified. This analysis is based on estimated reductions in NOx and PM emissions and uses a benefits transfer technique to determine the changes in human health and welfare, both in terms of physical effects and monetary value

These analyses yield a stream of monetized benefits which we compare to the costs of the standards. It is important to note that there are significant categories of benefits associated with the control program which cannot be monetized (or in many cases even quantified), including visibility, ozone health benefits, ecological effects, most species of air toxics' health and ecological effects. We identify these benefits in the discussion below and carry them through our estimates as nonmonetized health benefits.

10.2 General Methodology

10.2.1 PM Methodology - Benefits Transfer

In performing the analysis for the PM benefits, we relied on the results of a similar analysis performed for our emission controls for on-highway heavy-duty engines (called the

HD07 rule.[ll] see 99 FR 5002, January 18, 2001). This approach was necessary due to time and resource constraints. To apply that analysis to this control program, we used a benefits transfer technique, described below. Benefits transfer is the science and art of adapting primary benefits research from similar contexts to obtain the most accurate measure of benefits for the environmental quality change under analysis. Where appropriate, adjustments are made for the level of environmental quality change, the sociodemographic and economic characteristics of the affected population, and other factors in order to improve the accuracy and robustness of benefits estimates. Additional information on the technique used can be found in Hubbell 2002 memorandum to the Docket (Docket A-2000-01, Document IV-A-146).

The HD07 analysis followed the same general methodology used in the benefits analysis for the passenger vehicle Tier 2/Gasoline Sulfur final rule[mm] and other EPA air benefits reports, with routine updates in response to public comment and to reflect advances in modeling and the literature for economics and health effects. This analysis also reflects the advice of its independent Science Advisory Board (SAB) in determining the health and welfare effects considered in the benefits analysis and in establishing the most scientifically valid measurement and valuation techniques.

10.2.2 CO and Air Toxics Methodology : WTP

In this component of the analysis, we discuss the benefits of reducing air toxics pollution from vehicles subject to the rule. The only segment for which willingness to pay for reductions in pollution were reported in the literature was for use-values for snowmobiles; however, the estimates pertained only to use value and were not judged to be reliable. There were no studies estimating the changes in consumer surplus to other non-snowmobilers such as cross-country skiers, nature enthusiasts, and residents near where snowmobiles are operated. We are not able to estimate the value of changes in air toxics or CO from other engines subject to this rule.

[ll] Additional information about the Regulatory Model System for Aerosols and Deposition (REMSAD) and our modeling protocols can be found in our Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, document EPA420-R-00-026, December 2000. Docket No. A-2000-01, Document No. A-II-13. This document is also available at http://www.epa.gov/otaq/disel.htm#documents. Information can also be found in the docket for the HD07 rulemaking: A-99-06.

[mm] US EPA. Regulatory Impact Analysis: Control of Air Pollution from New Motor Vehicles: Tier 2 Emission Standards. Report No EPA420-R-99-023. December 1999. A copy of this document can be found in Docket A-99-06, Document IV-A-09.

10.2.3 Benefits Quantification

We use the term *benefits* to refer to any and all positive effects of emissions changes on social welfare that we expect to result from the final rule. We use the term environmental costs (also commonly referred to as "disbenefits") to refer to any and all negative effects of emissions changes on social welfare that result from the final rule. We include both benefits and environmental costs in this analysis. Where it is possible to quantify benefits and environmental costs, our measures are those associated with economic surplus in accepted applications of welfare economics. They measure the value of changes in air quality by estimating (primarily through benefits transfer) the willingness of the affected population to pay for changes in environmental quality and associated health and welfare effects.

Not all the benefits of the rule can be estimated with sufficient reliability to be quantified and included in monetary terms. The omission of these items from the total of monetary benefits reflects our inability to measure them. It does not indicate their lack of importance in the consideration of the benefits of this rulemaking.

This analysis presents estimates of the potential benefits from the Large SI/Recreational Vehicle rule expected to occur in 2030 as well as a stream of benefits and net present value from 2002 to 2030. The predicted emissions reductions that will result from the rule have yet to occur, and therefore the actual changes in human health and welfare outcomes to which economic values are ascribed are predictions. These predictions are based on the best available scientific evidence and judgment, but there is unavoidable uncertainty associated with each step in the complex process between regulation and specific health and welfare outcomes.

Changes in ambient concentrations will lead to new levels of environmental quality in the U.S., reflected both in human health and in non-health welfare effects. Thus, the predicted changes in ambient air quality serve as inputs into functions that predict changes in health and welfare outcomes. We use the term "endpoints" to refer to specific effects that can be associated with changes in air quality. Table 10.2-1 lists the human health and welfare effects identified for changes in air quality as they related to ozone, PM, CO, and HC.[nn] This list includes both those effects quantified (and/or monetized) in this analysis and those for which we are unable to provide quantified estimates.

For changes in risks to human health from changes in PM, quantified endpoints include changes in mortality and in a number of pollution-related non-fatal health effects. Only the benefits related to changes in NOx-related PM and directly emitted PM were estimated for Large SI. HC-related PM and any PM-related benefits for recreational marine, ATVs, OHMs, and

[nn] The HC listed in Table 10.2-1 are also listed as hazardous air pollutants in the Clean Air Act. We are not able to quantify their direct effects. To the extent that they are precursors to ozone or PM, they are included in our quantitative results.

snowmobiles were not estimated because of uncertainties with the benefits transfer to those categories and due to lack of information about HC-related PM from the original data set.

The benefits related to changes in CO and HC are not directly quantified for our primary analysis due to a lack of direct estimates of willingness to pay or appropriate exposure and air quality models for these pollutants.

Table 10.2-1
Human Health and Welfare Effects of Pollutants Affected by the Large SI/Recreational Vehicle Rule

Pollutant/Effect	Primary Quantified and Monetized Effects[A]	Unquantified Effects
Ozone/Health	Not quantified in this analysis	Minor restricted activity days Hospital admissions - respiratory and cardiovascular Emergency room visits for asthma Non-asthma respiratory emergency room visits Asthma symptoms Chronic asthma[C] Premature mortality[D] Increased airway responsiveness to stimuli Inflammation in the lung Chronic respiratory damage Premature aging of the lungs Acute inflammation and respiratory cell damage Increased susceptibility to respiratory infection
Ozone/Welfare	Not quantified in this analysis	Decreased worker productivity Decreased yields for commercial crops Decreased commercial forest productivity Decreased yields for fruits and vegetables Decreased yields for other commercial and non-commercial crops Damage to urban ornamental plants Impacts on recreational demand from damaged forest aesthetics Damage to ecosystem functions

Pollutant/Effect	Primary Quantified and Monetized Effects[A]	Unquantified Effects
PM/Health	Premature mortality Bronchitis - chronic and acute Hospital admissions - respiratory and cardiovascular[B] Emergency room visits for asthma Asthma attacks Lower and upper respiratory illness Minor restricted activity days Work loss days	Infant mortality Low birth weight Changes in pulmonary function Chronic respiratory diseases other than chronic bronchitis Morphological changes Altered host defense mechanisms Cancer Non-asthma respiratory emergency room visits
PM/Welfare	Not quantified in this analysis	Visibility in areas where people live, work and recreate Visibility in Class I national parks and forest areas Household soiling Materials damage
Nitrogen and Sulfate Deposition/ Welfare	Not quantified in this analysis	Impacts of acidic sulfate and nitrate deposition on commercial forests Impacts of acidic deposition on commercial freshwater fishing Impacts of acidic deposition on recreation in terrestrial ecosystems Impacts of nitrogen deposition on commercial fishing, agriculture, and forests Impacts of nitrogen deposition on recreation in estuarine ecosystems Costs of nitrogen controls to reduce eutrophication in estuaries Reduced existence values for currently healthy ecosystems
NO_x/Health	Not quantified in this analysis	Lung irritation Lowered resistance to respiratory infection Hospital Admissions for respiratory and cardiac diseases
CO/Health	Not quantified in this analysis As a supplemental calculation, some behavior effects (choice-reaction time) are quantified for one category for which an exposure model was available	Premature mortality[B] Behavioral effects Hospital admissions - respiratory, cardiovascular, and other Other cardiovascular effects Developmental effects Decreased time to onset of angina Non-asthma respiratory ER visits

Pollutant/Effect	Primary Quantified and Monetized Effects[A]	Unquantified Effects
HCs [E] Health	Not quantified in this analysis As a supplemental calculation, some behavior effects (choice-reaction time and toluene) are quantified for one category for which an exposure model was available	Cancer (diesel PM, benzene, 1,3-butadiene, formaldehyde, acetaldehyde) Anemia (benzene) Disruption of production of blood components (benzene) Reduction in the number of blood platelets (benzene) Excessive bone marrow formation (benzene) Depression of lymphocyte counts (benzene) Reproductive and developmental effects (1,3-butadiene) Irritation of eyes and mucous membranes (formaldehyde) Respiratory and respiratory tract Asthma attacks in asthmatics (formaldehyde) Asthma-like symptoms in non-asthmatics (formaldehyde) Irritation of the eyes, skin, and respiratory tract (acetaldehyde) Upper respiratory tract irritation & congestion (acrolein)
HCs [E] Welfare	Not quantified in this analysis	Direct toxic effects to animals Bioaccumulation in the food chain

[A] Primary quantified and monetized effects are those included when determining the base-case estimate of total monetized benefits of the Large SI/Recreational Vehicle rule.

[B] Our examination of the original studies used in this analysis finds that the health endpoints that are potentially affected by the GAM issues include: reduced hospital admissions and reduced lower respiratory symptoms. While resolution of these issues is likely to take some time, the preliminary results from ongoing reanalyses of some of the studies suggest a more modest effect of the S-plus error than reported for the NMMAPS PM_{10} mortality study. While we wait for further clarification from the scientific community, we have chosen not to remove these results from the benefits estimates, nor have we elected to apply any interim adjustment factor based on the preliminary reanalyses. EPA will continue to monitor the progress of this concern, and make appropriate adjustments as further information is made available.

[C] While no causal mechanism has been identified linking new incidences of chronic asthma to ozone exposure, an epidemiological study shows a statistical association between long-term exposure to ozone and incidences of chronic asthma in some non-smoking men (McDonnell, et al., 1999).

[D] Premature mortality associated with ozone is not separately included in this analysis. It is assumed that the American Cancer Society (ACS)/ Krewski, et al., 2000 C-R function we use for premature mortality captures both PM mortality benefits and any mortality benefits associated with other air pollutants (ACS/ Krewski, et al., 2000).

[E] Many of the hydrocarbons (HCs) listed in the table are also hazardous air pollutants listed in the Clean Air Act.

This remainder of this chapter proceeds as follows: in Sections 10.3, we describe the categories of benefits that are estimated, present the techniques and inputs that are used, and provide a discussion of how we incorporate uncertainty into our analysis. In Section 10.4, we briefly discuss the CO and air toxics benefits in a qualitative manner. In Section 10.5, we report our estimates of total monetized benefits.

10.3 PM-Related Health Benefits Estimation

10.3.1 Emissions Inventory Implications

The national inventories for NOx, HC, CO and PM have already been presented and discussed in Chapters 1 and 6 and in the supporting documents referenced in those chapters. Interested readers desiring more information about the inventory methodologies or results should consult that chapter for details. This section explains the specific inventories that were used in our quantitative estimates of benefits and the implications of those inventories related to interpreting results.

As noted in the previous section, this analysis focuses on the PM-related health benefits from emission reductions from Large SI engines only. To quantify these PM-related health benefits, we used NOx and direct PM emission changes (both reductions and increases, where applicable) for the categories Large SI. Our underlying air quality modeling which forms the basis for the transfer technique considers NOx as a precursor for both PM and ozone; thus, oxidant chemistry in the model would not lead to over-estimation of secondary PM formation. We did not include HC-related PM because we do not currently have an appropriate transfer technique.

We did not quantify the NOx, direct PM, or HC-related PM benefits for ATVs, OHMs, recreational marine diesels or snowmobiles because in our judgement there are substantial uncertainties in making the transfer from the on-highway vehicle modeling to these categories. This is because their operating characteristics and the locations in which these nonroad engines are used can be very different from on-highway vehicles. We had more reason to believe that the distribution of vehicles with respect to human populations was more similar for Large SI. However, in the analyses of alternatives, we present a sensitivity calculation for ATVs, noting the large uncertainties inherent in that application of this technique.

As described in the previous chapters of this Regulatory Support Document, the emission controls for Large SI engines and recreational vehicles begin at various times and in some cases phase in over time. This means that during the early years of the program there would not be a consistent match between cost and benefits. This is especially true for the vehicle control portions and initial fuel changes required by the program, where the full vehicle cost would be incurred at the time of vehicle purchase, while the fuel cost along with the emission reductions and benefits resulting from all these costs would occur throughout the lifetime of the vehicle. Because of this inconsistency and our desire to more appropriately match the costs and emission reductions of our program, our analysis uses a future year when the fleet is nearly fully turned over (2030). Consequently, we developed emission inventories through 2030 for both baseline conditions and a control scenario. We present both the benefits as a snapshot in 2030 and as a stream of benefits in the years leading up to 2030. However, our discussion of this analysis focuses on 2030 because the benefits transfer technique applied to these inventories relies on air quality modeling conducted for the year 2030.

10.3.2 Benefits Transfer Methodology

This section summarizes the benefits transfer methodology used in this analysis. This method provides a relatively simple analysis of the health costs of NO_x, and direct PM emissions from Large SI engines. It is important to distinguish these estimates from an analysis that employs full-scale air quality modeling and benefits modeling. The transfer technique used here produces reasonable approximations. Nevertheless, the method also adds uncertainty to the analysis and the results may under or overstate actual benefits of the control program.

Our approach is to develop estimates of health costs expressed in per ton terms. From the Regulatory Model System for Aerosols and Deposition (REMSAD) air quality modeling used for the HD07 rule benefits analysis, we estimated environmental and health costs per ton of NOx and PM. Aggregate environmental and health cost estimates at the national level are scaled to account for human population changes between years of analysis. Complete details of the emissions, air quality, and benefits modeling conducted for the HD07 rule can be found at http://www.epa.gov/otaq/diesel.htm and http://www.epa.gov/ttn/ecas/regdata/tsdhddv8.pdf. Further details of the transfer technique calculations and inputs can be found in the supporting memorandum to the docket (Hubbell 2002a). An alternative approach is presented to provide some insight into the potential of importance of key elements underlying estimates of benefits (Hubbell 2002b).

We examined the impacts of NOx, and direct PM emissions. NOx emissions are associated with both ambient ozone and particulate matter (PM) levels. Due to data limitations, we are providing estimates only for PM related health impacts. The underlying REMSAD modeling partitions the NOx into formation of both ozone and PM in 2030, oxidant chemistry in the model would not lead to over-estimation of secondary PM formation.[oo] Note that we do not attempt to quantify ozone-related benefits. Because the vast majority of the benefits we are able

[oo]Additional information about the Regulatory Model System for Aerosols and Deposition (REMSAD) and our modeling protocols can be found in our Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, document EPA420-R-00-026, December 2000. Docket No. A-2000-01, Document No. A-II-13. This document is also available at http://www.epa.gov/otaq/disel.htm#documents. Information can also be found in the docket for the HD07 rulemaking: A-99-06.

to measure and place a monetary value on are PM related, these estimates will capture most of the benefits we are able to monetize associated with the NO_x, and direct PM emission control. However, one important limitation is that benefits from ozone reductions, air toxics reductions, visibility improvement, and other unquantifiable health and welfare endpoints are not captured in these estimates. The results of this original analysis are summarized in Table 10.3-1.

The cost-per-ton estimate presented in Table 10.3-1 is for estimating tons reduced in 2001 based on a U.S. population of 277 million people. To apply this figure to future years, it is necessary to adjust for increases in population (e.g., in 2030, the U.S. population is estimated to be 345 million) and for growth in real income (see Hubbell 2002a and Equation 1 below).

Table 10.3-1
Summary of Health Effects and Economic Cost Estimates for Transfer

Health Effect[a]	Incidence/ton in 2001 based on U.S. population of 277 million		Estimated $/ton economic costs in 2001 based on U.S. population of 277 million (1999$)	
	NO_x	PM	NO_x	PM
All-cause Premature Mortality from Long-term Exposure	0.0016	0.0221	$9,726	$136,164
Chronic Bronchitis	0.0010	0.0143	$350	$5,012
Hospital Admissions - COPD	0.0002	0.0024	$2	$30
Hospital Admissions - Pneumonia	0.0002	0.0030	$3	$44
Hospital Admissions - Asthma	0.0002	0.0023	$1	$15
Hospital Admissions - Total Cardiovascular	0.0005	0.0072	$10	$132
Asthma-Related ER Visits	0.0004	0.0053	$0	$2
Asthma Attacks	0.0324	0.4566	$1	$19
Acute Bronchitis	0.0034	0.0479	<$1	$3
Upper Respiratory Symptoms	0.0368	0.5188	$1	$13
Lower Respiratory Symptoms	0.0373	0.5270	$1	$8
Work Loss Days	0.2849	4.0180	$30	$402
Minor Restricted Activity Days (minus asthma attacks)	1.3875	20.9184	$68	$1,023
Totals			$10,193	$142,867

Note that the wide discrepancy between the per ton values of NO_x and direct PM is due to differences in their relative contributions to ambient concentrations of $PM_{2.5}$. The underlying REMSAD modeling partitions NOx between ozone and secondary PM formation.The HD07 analysis examined the impacts in 2030 of reducing SO_2 emissions by 141,000 tons and NO_x emissions by 2,570,000 tons, as well as a 109,000 ton reduction in direct PM emissions.

[a] Our examination of the original studies used in this analysis finds that the health endpoints that are potentially affected by the GAM issues include: reduced hospital admissions and reduced lower respiratory symptoms. While resolution of these issues is likely to take some time, the preliminary results from ongoing reanalyses of some of the studies suggest a more modest effect of the S-plus error than reported for the NMMAPS PM_{10} mortality study. While we wait for further clarification from the scientific community, we have chosen not to remove these results from the benefits estimates, nor have we elected to apply any interim adjustment factor based on the preliminary reanalyses. EPA will continue to monitor the progress of this concern, and make appropriate adjustments as further information is made available.

10.3.3 Overview of Heavy Duty Engine/Diesel Fuel Benefits Analysis and Development of Benefits Transfer Technique

This section provides an overview of the original Heavy Duty Engine/Diesel Fuel 2007 rule (HD07) benefits analysis as it relates to the development of a benefits transfer technique. The HD07 analysis examined the impacts in 2030 of reducing SO_2 emissions by 141,000 tons and NO_x emissions by 2,570,000 tons, as well as a 109,000 ton reduction in direct PM emissions. Table 10.3-2 summarizes the NOx and direct PM results in aggregate and on a per ton basis.

Table 10.3-2
Summary of Results from 2030 HD Engine/Diesel Fuel Health Benefits Analysis

Health Outcome	NO_x Avoided Incidences Total	NO_x Avoided Incidences Per Ton	PM Avoided Incidences Total	PM Avoided Incidences Per Ton
Premature Mortality				
All-cause premature mortality from long-term exposure	5,027	0.00196	3,007	0.02759
Chronic Illness				
Chronic Bronchitis (pooled estimate)	3,243	0.00126	1,941	0.01781
Hospital Admissions				
COPD	554	0.00022	331	0.00304
Pneumonia	676	0.00026	404	0.00371
Asthma	523	0.00002	313	0.00289
Total Cardiovascular	1,635	0.00064	978	0.00897
Asthma-Related ER Visits	1,209	0.00047	723	0.00663
Other Effects				
Asthma Attacks	103,905	0.04043	62,135	0.57005
Acute Bronchitis	10,874	0.00423	6,515	0.05977
Upper Respiratory Symptoms	118,063	0.04594	70,601	0.64771
Lower Respiratory Symptoms	119,760	0.04660	71,711	0.65790
Work Loss Days	914,055	0.35566	546,744	5.01600
Minor Restricted Activity Days (minus asthma attacks)	4,763,239	1.85300	2,846,434	26.11407

In the original HD07 analyses, we used the air quality model, REMSAD, which is a three-dimensional grid-based Eulerian air quality model designed to estimate annual particulate concentrations and deposition over large spatial scales (e.g., over the contiguous U.S.) as summarized in Chapter 1 above. The HD07 RIA benefits analysis applies the modeling system to the entire U.S. for two future-year scenarios: a 2030 base case and a 2030 HD Engine/Diesel Fuel control scenario. The PM species modeled by REMSAD include a primary fine fraction (corresponding to particulates less than 2.5 microns in diameter) and several secondary particles (e.g., sulfates, nitrates, and organics). $PM_{2.5}$ is calculated as the sum of the primary fine fraction and all of the secondary particles.

For the purposes of this analysis, we separated the predicted 2030 change in the primary and secondarily-formed components of $PM_{2.5}$ (i.e., sulfates and nitrates) to provide attributable health effects for SO_2 and NO_x. We did this by separating these chemically speciated fractions of PM (e.g., particulate elemental carbon, and total organic aerosols, sulfate, and particulate nitrate (PNO_3)). It is reasonable to separate these predicted concentrations because of the limited interactions of secondary sulfate and nitrates within the modeling system and the limited contribution of secondary organic aerosols (SOA) to TOA (i.e., since there little or no change in HCs in the original HD07 scenario). Because the original HD07 modeling did not examine the type of HC reductions that are present in this rulemaking, we are not able to create a transfer technique for the HC that would contribute to PM formation. Thus, we limit our consideration of secondary formation of PM to the NO_x emissions in this analysis.

To develop the NOx transfer values, we estimated the incidences of the health endpoints we are able to quantify using the population weighted change in nitrate of -0.388 micrograms per cubic meter into each of the concentration-response functions used in the HD07 benefits analysis. This yields estimates of the health effects associated with the NO_x emission reductions. Based on 2030 populations, this change leads to the estimated reductions in health effects listed in the second column of Table 10.3-2. Note that for concentration response (C-R) functions that use daily average $PM_{2.5}$ or PM_{10} levels, use of the annual mean as a proxy for daily averages will over or underestimate the annual incidence by a small amount (less than five percent). We then divided the attributable incidences by NO_x tons reduced in the HD07 analysis, resulting in incidences per ton of NO_x reduced in 2030 as listed in the third column of Table 10.3-2. We then scaled the incidences per ton by the ratio of population in the year of analysis to population in 2030 to obtain incidences per ton for each year (Hubbell 2002).

We conducted a similar operation to develop coefficients for direct PM. In this instance, we started with the population-weighted change in primary PM of -0.232 micrograms per cubic meter in the HD07 analysis.

$$Benefits_{YearI} = \sum I_{P,E} \times T_{YearI,p} \times RatioPop_{YearI} \times Value_{YearI,E} \quad \textbf{[1]}$$

Where

$Benefits_{YearI}$ = Monetized Benefits in Year *I*, pollutant *P*

$I_{P,E}$ = Avoided Incidence per ton pollutant *P* for endpoint *E*

$T_{year\ I,p}$ = Tons pollutant *P* in Year *I*

$RatioPop_{YearI}$ = Population ratio between year of analysis and 2030

$Value_{YearI,E}$ = Monetary value per avoided incidence of endpoint *E* in Year *I*

10.3.4. Quantifying and Valuing Individual Health Endpoints

This section summarizes the studies used to calculate the health incidences and valuation of those incidences both in the original HD07 benefits analysis and relied on here. Quantifiable health benefits of the final Large SI/Recreational Vehicle rule may be related to PM only, or both PM and ozone. We are not estimating any ozone-related benefits, so this analysis is only a partial quantification of the benefits associated with the emission controls for these categories. PM-only health effects include premature mortality, chronic bronchitis, acute bronchitis, upper and lower respiratory symptoms, and work loss days.[pp] Health effects related to both PM and ozone include hospital admissions, asthma attacks, and minor restricted activity days.

For this analysis, we rely on concentration response (C-R) functions estimated in published epidemiological studies relating serious health effects to ambient air quality. The specific studies from which C-R functions are drawn are included in Table 10.3-3. A complete discussion of the C-R functions used for this analysis and information about each endpoint are contained in the HD07 RIA and supporting documents. It is important to note that although there may be biologically relevant differences between direct PM from diesels and from gasoline engines, the primary health studies on which the HD07 benefits assessment is based relied on ambient measurements of PM, not diesel-specific exposure information. Thus, we avoid an uncertainty of transferring a diesel-PM health estimate to gasoline-PM situation.

While a broad range of serious health effects have been associated with exposure to elevated PM levels (as noted for example in Table 10.2-1 and described more fully in the ozone and PM Criteria Documents (US EPA, 1996a, 1996b), we include only a subset of health effects in this quantified benefit analysis. Health effects are excluded from this analysis for four reasons:

(i) lack of an adequate benefits transfer technique;
(ii) the possibility of double counting (such as hospital admissions for specific respiratory diseases);

[pp] Some evidence has been found linking both PM and ozone exposures with premature mortality. The SAB has raised concerns that mortality-related benefits of air pollution reductions may be overstated if separate pollutant-specific estimates, some of which may have been obtained from models excluding the other pollutants, are aggregated. In addition, there may be important interactions between pollutants and their effect on mortality (EPA-SAB-Council-ADV-99-012, 1999; a copy of this document is available in Docket A-99-06, Document IV-A-20). Because of concern about overstating of benefits and because the evidence associating mortality with exposure to PM is currently stronger than for ozone, only the benefits related to the long-term exposure study (ACS/Krewkski, et al, 2000) of mortality are included in the total primary benefits estimate. A copy of Krewski, et al., can be found in Docket A-99-06, Document No. IV-G-75.

(iii) uncertainties in applying effect relationships based on clinical studies to the affected population; and
(iv) a lack of an established C-R relationship.

Table 10.3-3
Endpoints and Studies Included in the Primary Analysis

Endpoint	Study	Study Population
Premature Mortality		
Long-term exposure	Krewski, et al. (2000)[A]	Adults, 30 and older
Chronic Illness		
Chronic Bronchitis (pooled estimate)	Abbey, et al. (1995) Schwartz, et al. (1993)	> 26 years > 29 years
Hospital Admissions		
COPD	Samet, et al. (2000)	> 64 years
Pneumonia	Samet, et al. (2000)	> 64 years
Asthma	Sheppard, et al. (1999)	< 65 years
Total Cardiovascular	Samet, et al. (2000)	> 64 years
Asthma-Related ER Visits	Schwartz, et al. (1993)	All ages
Other Illness		
Asthma Attacks	Whittemore and Korn (1980)	Asthmatics, all ages
Acute Bronchitis	Dockery et al. (1996)	Children, 8-12 years
Upper Respiratory Symptoms	Pope et al. (1991)	Asthmatic children, 9-11
Lower Respiratory Symptoms	Schwartz et al. (1994)	Children, 7-14 years
Work Loss Days	Ostro (1987)	Adults, 18-65 years
Minor Restricted Activity Days (minus asthma attacks)	Ostro and Rothschild (1989)	Adults, 18-65 years

[A] Estimate derived from Table 31, PM2.5(DC), All Causes Model (Relative Risk =1.12 for a 24.5 $\mu g/m^3$ increase in mean $PM_{2.5}$).

Recently, the Health Effects Institute (HEI) reported findings by investigators at Johns Hopkins University and others that have raised concerns about aspects of the statistical methodology used in a number of recent time-series studies of short-term exposures to air pollution and health effects (Greenbaum, 2002). Some of the concentration-response functions used in this benefits analysis were derived from such short-term studies. The estimates derived from the long-term mortality studies, which account for a major share of the benefits in the Base

Estimate, are not affected. As discussed in HEI materials provided to sponsors and to the Clean Air Scientific Advisory Committee (Greenbaum, 2002) these investigators found problems in the default "convergence criteria" used in Generalized Additive Models (GAM) and a separate issue first identified by Canadian investigators about the potential to underestimate standard errors in the same statistical package.[qq] These and other investigators have begun to reanalyze the results of several important time series studies with alternative approaches that address these issues and have found a downward revision of some results. For example, the mortality risk estimates for short-term exposure to PM_{10} from The National Morbidity, Mortality and Air Pollution Study (NMMAPS) were overestimated (this study was *not* used in this benefits analysis of fine particle effects).[rr] However, both the relative magnitude and the direction of bias introduced by the convergence issue is case-specific. In most cases, the concentration-response relationship may be overestimated; in other cases, it may be underestimated. The preliminary reanalyses of the mortality and morbidity components of NMMAPS suggest that analyses reporting the lowest relative risks appear to be affected more greatly by this error than studies reporting higher relative risks (Dominici et al., 2002; Schwartz and Zanobetti, 2002).

Our examination of the original studies used in this analysis finds that the health endpoints that are potentially affected by the GAM issues include: reduced hospital admissions and reduced lower respiratory symptoms in the both the Base and Alternative Estimates; and reduced premature mortality due to short-term PM exposures in the Alternative Estimate. While resolution of these issues is likely to take some time, the preliminary results from ongoing reanalyses of some of the studies used in our analyses (Dominici et al, 2002; Schwartz and Zanobetti, 2002; Schwartz, personal communication 2002) suggest a more modest effect of the S-plus error than reported for the NMMAPS PM_{10} mortality study. While we wait for further clarification from the scientific community, we have chosen not to remove these results from the estimated benefits, nor have we elected to apply any interim adjustment factor based on the preliminary reanalyses. EPA will continue to monitor the progress of this concern, and make appropriate adjustments as further information is made available.

In Table 10.3-4, we present how we have valued the estimated changes in health effects and the value functions selected from the peer reviewed literature to provide monetized estimates. One of the most important effects is premature mortality. While the base value for a mortality incidence is $6.1 million (1999$), this number is always adjusted downward to reflect the impact of discounting over the assumed 5 year lag period between reductions in PM concentrations and full realization of reduced mortality. The lag-adjusted base VSL is $5.8

[qq]Most of the studies used a statistical package known as "S-plus." For further details, see http://www.healtheffects.org/Pubs/NMMAPSletter.pdf.

[rr]HEI sponsored the multi-city the National Morbidity, Mortality, and Air Pollution Study (NMMAPS). See http://biosun01.biostat.jhsph.edu/~fdominic/NMMAPS/nmmaps-revised.pdf for revised mortality results. A copy of this document can be found in Docket A-2000-01, Document IV-A-201.

million (1999$) when a 3% discount rate is assumed. Thus the attached table reflects income adjustments applied to these lag adjusted base values.

Table 10.3-4
Unit Values Used for Economic Valuation of Health Endpoints

Health or Welfare Endpoint	Estimated Value per Incidence (1999$) Central Estimate	Derivation of Estimates
Respiratory Ailments Not Requiring Hospitalization		
Premature Mortality	$6 million per statistical life	Value is the mean of value-of-statistical-life estimates from 26 studies (5 contingent valuation and 21 labor market studies) reviewed for the Section 812 Costs and Benefits of the Clean Air Act, 1990-2010 (US EPA, 1999).
Chronic Bronchitis (CB)	$331,000	Value is the mean of a generated distribution of WTP to avoid a case of pollution-related CB. WTP to avoid a case of pollution-related CB is derived by adjusting WTP (as described in Viscusi et al., 1991) to avoid a severe case of CB for the difference in severity and taking into account the elasticity of WTP with respect to severity of CB.
Hospital Admissions		
Chronic Obstructive Pulmonary Disease (COPD) (ICD codes 490-492, 494-496)	$12,378	The COI estimates are based on ICD-9 code level information (e.g., average hospital care costs, average length of hospital stay, and weighted share of total COPD category illnesses) reported in Elixhauser (1993).
Pneumonia (ICD codes 480-487)	$14,693	The COI estimates are based on ICD-9 code level information (e.g., average hospital care costs, average length of hospital stay, and weighted share of total pneumonia category illnesses) reported in Elixhauser (1993).
Asthma admissions	$6,634	The COI estimates are based on ICD-9 code level information (e.g., average hospital care costs, average length of hospital stay, and weighted share of total asthma category illnesses) reported in Elixhauser (1993).
All Cardiovascular (ICD codes 390-429)	$18,387	The COI estimates are based on ICD-9 code level information (e.g., average hospital care costs, average length of hospital stay, and weighted share of total cardiovascular illnesses) reported in Elixhauser (1993).
Emergency room visits for asthma	$299	COI estimate based on data reported by Smith, et al. (1997).
Respiratory Ailments Not Requiring Hospitalization		
Upper Respiratory Symptoms (URS)	$24	Combinations of the 3 symptoms for which WTP estimates are available that closely match those listed by Pope, et al. result in

Lower Respiratory Symptoms (LRS)	$15	Combinations of the 4 symptoms for which WTP estimates are available that closely match those listed by Schwartz, et al. result in 11 different "symptom clusters," each describing a "type" of LRS. A dollar value was derived for each type of LRS, using mid-range estimates of WTP (IEc, 1994) to avoid each symptom in the cluster and assuming additivity of WTPs. The dollar value for LRS is the average of the dollar values for the 11 different types of LRS.
Acute Bronchitis	$57	Average of low and high values recommended for use in Section 812 analysis (Neumann, et al. 1994)
Restricted Activity and Work Loss Days		
Work Loss Days (WLDs)	Variable	Regionally adjusted median weekly wage for 1990 divided by 5 (adjusted to 1999$) (US Bureau of the Census, 1992).
Minor Restricted Activity Days (MRADs)	$48	Median WTP estimate to avoid one MRAD from Tolley, et al. (1986) .

10.3.5. Estimating Monetized Benefits Anticipated in Each Year

We applied these estimates of the value per incidence to calculate a stream of benefits in future years. We scaled the benefits to the appropriate future year national populations to reflect growth in population. Our projections reflect the U.S. Bureau of the Census predictions.

Our analysis accounts for expected growth in real income over time. Economic theory argues that willingness to pay (WTP) for most goods (such as environmental protection) will increase if real incomes increase. There is substantial empirical evidence that the income elasticity[ss] of WTP for health risk reductions is positive, although there is uncertainty about its exact value. Thus, as real income increases the WTP for environmental improvements also increases. While many analyses assume that the income elasticity of WTP is unit elastic (i.e., ten percent higher real income level implies a ten percent higher WTP to reduce risk changes), empirical evidence suggests that income elasticity is substantially less than one and thus relatively inelastic. As real income rises, the WTP value also rises but at a slower rate than real income.

The effects of real income changes on WTP estimates can influence benefit estimates in two different ways: (1) through real income growth between the year a WTP study was conducted and the year for which benefits are estimated, and (2) through differences in income between study populations and the affected populations at a particular time. Empirical evidence

[ss]Income elasticity is a common economic measure equal to the percentage change in WTP for a one percent change in income.

of the effect of real income on WTP gathered to date is based on studies examining the former. The Environmental Economics Advisory Committee (EEAC) of the SAB advised EPA to adjust WTP for increases in real income over time, but not to adjust WTP to account for cross-sectional income differences “because of the sensitivity of making such distinctions, and because of insufficient evidence available at present” (EPA-SAB-EEAC-00-013).

Based on a review of the available income elasticity literature, we adjust the valuation of human health benefits upward to account for projected growth in real U.S. income. Faced with a dearth of estimates of income elasticities derived from time-series studies, we applied estimates derived from cross-sectional studies in our analysis. Details of the procedure can be found in Kleckner and Neumann (1999). An abbreviated description of the procedure we used to account for WTP for real income growth between 1990 and 2030 is presented in the HD07 TSD.

Incidences in future years will have different values based on adjustments to WTP for growth in income over time. (The schedule of adjustment factors and adjusted WTP values to be applied for each year is listed in attachment 2 of the Hubbell 2002, Docket A-2000-01, Document number IV-A-146.) Adjustment factors should not be applied to the values for avoided hospital admissions, as these are cost-of-illness estimates and not WTP estimates. Likewise, adjustment factors should not be applied to the value of work loss days, as this is a wage-based estimate, not WTP.

10.3.6. Methods for Describing Uncertainty

In any complex analysis using estimated parameters and inputs from numerous models, there are likely to be many sources of uncertainty.[tt] This analysis is no exception. As outlined both in this and preceding chapters, there are many inputs used to derive the final estimate of benefits, including emission inventories, air quality models (with their associated parameters and inputs), epidemiological estimates of C-R functions, estimates of values (both from WTP and cost-of-illness studies), population estimates, income estimates, and estimates of the future state of the world (i.e., regulations, technology, and human behavior). Each of these inputs may be uncertain, and depending on their location in the benefits analysis, may have a disproportionately large impact on final estimates of total benefits. For example, emissions estimates are a foundation of the analysis. As such, any uncertainty in emissions estimates will be propagated through the entire analysis. When compounded with uncertainty in later stages, small

[tt] It should be recognized that in addition to uncertainty, the annual benefit estimates for the final Large SI/Recreational Vehicle rule presented in this analysis are also inherently variable, due to the truly random processes that govern pollutant emissions and ambient air quality in a given year. Factors such as weather display constant variability regardless of our ability to accurately measure them. As such, the estimates of annual benefits should be viewed as representative of the types of benefits that will be realized, rather than the actual benefits that would occur every year.

uncertainties in emission levels can lead to much larger impacts on total benefits. A more thorough discussion of uncertainty can be found in the HD07 benefits TSD (Abt Associates, 2000).

Some key sources of uncertainty in each stage of the benefits analysis are:

- Gaps in scientific data and inquiry;
- Uncertainties in the benefit transfer process from the HD07 case to the vehicles covered in this rulemaking;
- Variability in estimated relationships, such as C-R functions, introduced through differences in study design and statistical modeling;
- Errors in measurement and projection for variables such as population growth rates;
- Errors due to misspecification of model structures, including the use of surrogate variables, such as using PM_{10} when $PM_{2.5}$ is not available, excluded variables, and simplification of complex functions; and
- Biases due to omissions or other research limitations.

Some of the key uncertainties in the benefits analysis are presented in Table 10.3-5. There are a wide variety of sources for uncertainty and the potentially large degree of uncertainty in our estimate. In the original HD07 benefits assessment, sensitivity analyses were performed including qualitative discussions, probabilistic assessments, alternative calculations, and bounding exercises. For some parameters or inputs it may be possible to provide a statistical representation of the underlying uncertainty distribution. For other parameters or inputs, the information necessary to estimate an uncertainty distribution is not available. Even for individual endpoints, there is usually more than one source of uncertainty. This makes it difficult to provide a quantified uncertainty estimate. For example, the C-R function used to estimate avoided premature mortality has an associated standard error which represents the sampling error around the pollution coefficient in the estimated C-R function. It would be possible to report a confidence interval around the estimated incidences of avoided premature mortality based on this standard error. However, this would omit the contribution of air quality changes, baseline population incidences, projected populations exposed, and transferability of the C-R function to diverse locations to uncertainty about premature mortality. Thus, a confidence interval based on the standard error would provide a misleading picture about the overall uncertainty in the estimates. Information on the uncertainty surrounding particular C-R and valuation functions is provided in the HD07 benefits TSD (Abt Associates, 2000). But, this information should be interpreted within the context of the larger uncertainty surrounding the entire analysis.

Many benefits categories, while known to exist, do not have enough information available to provide a quantified or monetized estimate. One significant limitation of both the health and welfare benefits analyses is the inability to quantify many of the serious effects listed in Table 10.2-1. The uncertainty regarding these endpoints is such that we could determine neither a primary estimate nor a plausible range of values. The net effect of excluding benefit and disbenefit categories from the estimate of total benefits depends on the relative magnitude of the effects.

Our estimate of total benefits should be viewed as an approximate result because of the sources of uncertainty discussed above (see Table 10.3-5). The total benefits estimate may understate or overstate actual benefits of the rule. In considering the monetized benefits estimates, the reader should remain aware of the many limitations of conducting these analyses mentioned throughout this chapter.

Table 10.3-5
Primary Sources of Uncertainty in the Benefit Analysis

1. Uncertainties Associated With Concentration-Response Functions	
-	The value of the PM-coefficient in each C-R function.
-	Application of a single C-R function to pollutant changes and populations in all locations.
-	Similarity of future year C-R relationships to current C-R relationships.
-	Correct functional form of each C-R relationship.
-	Extrapolation of C-R relationships beyond the range of PM concentrations observed in the study.
-	Application of C-R relationships only to those subpopulations matching the original study population.
2. Uncertainties Associated With Original Modeled Ambient PM Concentrations	
-	Responsiveness of the models to changes in precursor emissions resulting from the control policy.
-	Projections of future levels of precursor emissions, especially ammonia and crustal materials.
-	Model chemistry for the formation of ambient nitrate concentrations.
–	Comparison of model predictions of particulate nitrate with observed rural monitored nitrate levels indicates that REMSAD overpredicts nitrate in some parts of the Eastern US and underpredicts nitrate in parts of the Western US.
3. Uncertainties Associated with PM Mortality Risk	
-	No scientific literature supporting a direct biological mechanism for observed epidemiological evidence.
–	Direct causal agents within the complex mixture of PM have not been identified.
- the year	The extent to which adverse health effects are associated with low level exposures that occur many times in versus peak exposures.
–	The extent to which effects reported in the long-term exposure studies are associated with historically higher levels of PM rather than the levels occurring during the period of study.
-	Reliability of the limited ambient $PM_{2.5}$ monitoring data in reflecting actual $PM_{2.5}$ exposures.
4. Uncertainties Associated With Possible Lagged Effects	
- levels	The portion of the PM-related long-term exposure mortality effects associated with changes in annual PM would occur in a single year is uncertain as well as the portion that might occur in subsequent years.
5. Uncertainties Associated With Baseline Incidence Rates	

–	Some baseline incidence rates are not location-specific (e.g., those taken from studies) and may therefore not accurately represent the actual location-specific rates.
-	Current baseline incidence rates may not approximate well baseline incidence rates in 2030.
–	Projected population and demographics may not represent well future-year population and demographics.
6. Uncertainties Associated With Economic Valuation	
-	Unit dollar values associated with health and welfare endpoints are only estimates of mean WTP and therefore
have	uncertainty surrounding them.
–	Mean WTP (in constant dollars) for each type of risk reduction may differ from current estimates due to differences in income or other factors.
7. Uncertainties Associated With Aggregation of Monetized Benefits	
–	Health and welfare benefits estimates are limited to the available C-R functions. Thus, unquantified or unmonetized benefits are not included.
8. Uncertainties introduced by Transferring Benefits from a Previous Mobile Source Benefits Analysis	
–	The reasonableness of the benefits transfer depends on the similarity of the original analysis and the emission reductions analyzed with respect to the relationship between emissions and human populations.

10.3.7. Estimated Reductions in Incidences of Health Endpoints and Associated Monetary Values

Applying the techniques (including the C-R and valuation functions described above) to the estimated changes in NOx and direct PM emissions yields estimates of the number of avoided incidences (i.e. premature mortalities, cases, admissions, etc.) and the associated monetary values for those avoided incidences. These estimates are presented in Table 10.3-6 for 2030. All of the monetary benefits are in constant 2002 dollars.

Not all known PM- and ozone-related health effects could be quantified or monetized. These unmonetized benefits are indicated by place holders, labeled B_1 and B_2. In addition, unmonetized benefits associated with ozone, CO and HC reductions are indicated by the placeholders $B_{2,}$ $B_{3,}$ and B_4. Unquantified physical effects are indicated by U_1 through U_4. The estimate of total monetized health benefits is thus equal to the subset of monetized PM-related health benefits plus $\mathbf{B_H}$, the sum of the unmonetized health benefits.

The largest monetized health benefit is associated with reductions in the risk of premature mortality, which accounts for over $7.5 billion, which is over 95 percent of total monetized health benefits.[uu] The next largest benefit is for chronic bronchitis reductions, although this value

[uu] Alternative calculations for premature mortality incidences and valuation are presented in the HD07 RIA in Tables VII-24 and VII-25, respectively. An alternative calculation is also provided in Table VII-25 for chronic bronchitis incidences and for chronic asthma incidences. The HD07 RIA can be found in Docket A-2000-01, Document II-A-13.

is more than an order of magnitude lower than for premature mortality. Minor restricted activity days, work loss days, and worker productivity account for the majority of the remaining benefits. The remaining categories account for less than $10 million each; however, they represent a large number of avoided incidences affecting many individuals.

Table 10.3-6
Base-Case Estimate of Annual Health Benefits Associated With Air Quality Changes Resulting from the Large SI Requirements Only in 2030

Endpoint	Avoided Incidence[A] (cases/year)	Monetary Benefits[B] (millions 2002$, adjusted for growth in real income)
PM-related Endpoints[C]		
Premature mortality[D] (adults, 30 and over)	1,000	$7,510
Chronic bronchitis (adults, 26 and over)	640	$280
Hospital Admissions – Pneumonia (adults, over 64)	100	<$5
Hospital Admissions – COPD (adults, 64 and over)	100	<$5
Hospital Admissions – Asthma (65 and younger)	100	<$1
Hospital Admissions – Cardiovascular (adults, over 64)	300	<$10
Emergency Room Visits for Asthma (65 and younger)	300	<$1
Asthma Attacks (asthmatics, all ages)[E]	20,600	<$1
Acute bronchitis (children, 8-12)	2,200	<$1
Lower respiratory symptoms (children, 7-14)	23,700	<$1
Upper respiratory symptoms (asthmatic children, 9-11)	23,400	<$1
Work loss days (adults, 18-65)	181,300	$20
Minor restricted activity days (adults, age 18-65)	944,400	$50
Other PM-related health effects[E]	U_1	B_1
Ozone-related Endpoints	U_2	B_2
CO and HC-related health effects[E]	U_3+U_4	B_3+B_4
Monetized Total Health-related Benefits[G]	—	$7,880+$\mathbf{B_H}$

[A] Incidences are rounded to the nearest 100.

[B] Dollar values are rounded to the nearest $10 million.

[C] PM-related benefits are based on the assumption that Eastern U.S. nitrate reductions are equal to one-fifth the nitrate reductions predicted by REMSAD (see HD07 RIA Chapter II for a discussion of REMSAD and model performance).

[D] Premature mortality associated with ozone is not separately included in this analysis (also note that the estimated value for PM-related premature mortality assumes the 5 year distributed lag structure). Further, PM-related reductions are not quantified for ATVs, OHMs, snowmobiles and recreational marine diesel.

[E] A detailed listing of unquantified PM, ozone, CO, and HC related health effects is provided in Table 10.2-1.

[F] Based upon recent preliminary findings by the Health Effects Institute, the concentration-response functions used to estimate reductions in hospital admissions may over- or under-estimate the true concentration-response relationship. Our examination of the original studies used in

this analysis finds that the health endpoints that are potentially affected by the GAM issues include: reduced hospital admissions and reduced lower respiratory symptoms. While resolution of these issues is likely to take some time, the preliminary results from ongoing reanalyses of some of the studies suggest a more modest effect of the S-plus error than reported for the NMMAPS PM_{10} mortality study. While we wait for further clarification from the scientific community, we have chosen not to remove these results from the benefits estimates, nor have we elected to apply any interim adjustment factor based on the preliminary reanalyses. EPA will continue to monitor the progress of this concern, and make appropriate adjustments as further information is made available.
[G] $\mathbf{B_H}$ is equal to the sum of all unmonetized categories, i.e. $B_a+B_1+B_2+B_3+B_4$.

In Table 10.3-7, we present the benefits over time as the regulations phase in over time and a net present value, assuming a 3 percent social discount rate.

Table 10.3-7
Monetized Benefits for Large SI Category Only [A]

Year	Nox Reductions (tons)	PM Reductions (tons)	Total Large SI Benefits (thousands $)
2004	40117	0	$ 420,000
2005	74541	0	$ 800,000
2006	108754	0	$ 1,180,000
2007	152431	0	$ 1,670,000
2008	193218	0	$ 2,150,000
2009	233094	0	$ 2,630,000
2010	271554	0	$ 3,110,000
2011	306016	0	$ 3,820,000
2012	328022	0	$ 4,160,000
2013	347920	0	$ 4,480,000
2014	365688	0	$ 4,790,000
2015	378511	0	$ 5,030,000
2016	389820	0	$ 5,270,000
2017	400470	0	$ 5,490,000
2018	410477	0	$ 5,710,000
2019	419931	0	$ 5,900,000
2020	428805	0	$ 6,130,000
2021	437527	-1	$ 6,320,000
2022	446085	-1	$ 6,540,000
2023	454549	-1	$ 6,750,000
2024	462994	-1	$ 6,950,000
2025	471382	-1	$ 7,120,000
2026	479206	-1	$ 7,280,000
2027	486998	-1	$ 7,440,000
2028	494665	-1	$ 7,600,000
2029	502188	-1	$ 7,740,000
2030	509684	-1	$ 7,880,000
Net Present Value 2002 - 2030			$ 77,180,000

[A] This analysis excludes the health effects we are not able to quantify for PM, ozone, CO, and HC. A detailed list is provided in Table 10.2-1. Only NOx and PM reductions from Large SI are quantified. The sizable PM and Nox reductions from ATVs, OHMs, snowmobiles, and recreational marine diesel are not quantified.
[B] Dollar values are rounded to the nearest $10 million.
[c] A social discount rate of 3 percent is used to calculate the net present value. If a discount rate of 7 percent is used, the net present value (2002 - 2030) is $40.07 billion.

10.3.8 Alternative Calculations of Estimated Reductions in Incidences of Health Endpoints and Associated Monetary Values

We have also evaluated an alternative, more conservative estimate, that can provide useful insight into the potential impacts of the key elements underlying estimates of the benefits of reducing NOx, and PM emissions from this rule through calculated alternative benefits for mortality and chronic bronchitis. The alternative estimate of mortality reduction relies on certain recent available scientific studies. These studies found an association between increased mortality and short-term exposure to PM over days to weeks. The alternative approach uses different data on valuation and makes adjustments relating to the health status and potential longevity of the populations most likely affected by PM (for more details see Hubbell 2002b). We are continuing to examine the merits of applying this alternative approach to the calculation of benefits. Some of the issues that warrant further investigation are described below.

10.3.9 Alternative Calculations of PM Mortality Risk Estimates and Associated Monetary Values

The Alternative Estimate addresses uncertainty about the relationship between premature mortality and long-term exposures to ambient levels of fine particles by assuming that there is no mortality effect of chronic exposures to fine particles. Instead, it assumes that the full impact of fine particles on premature mortality can be captured using a concentration-response function relating daily mortality to short-term fine particle levels. Specifically, a concentration-response function based on Schwartz et al. (1996) is employed, with an adjustment to account for recent evidence that daily mortality is associated with particle levels from a number of previous days (Schwartz, 2000). Previous daily mortality studies (Schwartz et al., 1996) examined the impact of $PM_{2.5}$ on mortality on a single day or over the average of two or more days. Recent analyses have found that impacts of elevated $PM_{2.5}$ on a given day can elevate mortality on a number of following days (Schwartz, 2000; Samet et al., 2000). Multi-day models are often referred to as "distributed lag" models because they assume that mortality following a PM event will be distributed over a number of days following or "lagging" the PM event. [vv]

There are no $PM_{2.5}$ daily mortality studies which report numeric estimates of relative risks from distributed lag models; only PM_{10} studies are available. Daily mortality C-R functions for PM_{10} are consistently lower in magnitude than $PM_{2.5}$-mortality C-R functions, because fine particles are believed to be more closely associated with mortality than the coarse fraction of PM. Given that the emissions reductions from heavy duty vehicles result primarily in reduced ambient concentrations of $PM_{2.5}$, use of a PM_{10} based C-R function results in a significant downward bias in the estimated reductions in mortality. To account for the full potential multi-day mortality

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[vv] It is of note that, based on recent preliminary findings from the Health Effects Institute (http://www.healtheffects.org), the magnitude of mortality from short-tern exposure may be under or overestimated.

impact of acute $PM_{2.5}$ events, we use the distributed lag model for PM_{10} reported in Schwartz (2000) to develop an adjustment factor which we then apply to the $PM_{2.5}$ based C-R function reported in Schwartz et al. (1996). If most of the increase in mortality is expected to be associated with the fine fraction of PM_{10}, then it is reasonable to assume that the same proportional increase in risk would be observed if a distributed lag model were applied to the $PM_{2.5}$ data. There are two relevant coefficients from the Schwartz et al. (1996) study, one corresponding to all-cause mortality, and one corresponding to chronic obstructive pulmonary disease (COPD) mortality (separation by cause is necessary to implement the life years lost approach detailed below).

These estimates, while approximating the full impact of daily pollution levels on daily death counts, do not capture any impacts of long-term exposure to air pollution. EPA's Science Advisory Board, while acknowledging the uncertainties in estimation of a PM-mortality relationship, has recommended the use of a study that does reflect the impacts of long-term exposure. The omission of long-term impacts accounts for an approximately 40 percent reduction in the estimate of avoided premature mortality in the alternative estimates relative to the primary estimates.

Furthermore, the alternative estimates reflect the impact of changes to key assumptions associated with the valuation of mortality. These include: 1) the impact of using wage-risk and contingent valuation-based value of statistical life estimates in valuing risk reductions from air pollution as opposed to contingent valuation-based estimates alone, 2) the relationship between age and willingness-to-pay for fatal risk reductions, and 3) the degree of prematurity in mortalities from air pollution.

The alternative estimates address this issue by using an estimate of the value of statistical life that is based only on the set of five contingent valuation studies included in the larger set of 26 studies recommended by Viscusi (1992) as applicable to policy analysis. The mean of the five contingent valuation based VSL estimates is $3.7 million (1999$), which is approximately 60 percent of the mean value of the full set of 26 studies.

The second issue is addressed by assuming that the relationship between age and willingness-to-pay for fatal risk reductions can be approximated using an adjustment factor derived from Jones-Lee (1989). The SAB has advised the EPA that the appropriate way to account for age differences is to obtain the values for risk reductions from the age groups affected by the risk reduction.

To show the maximum impact of the age adjustment, the Alternative Estimate is based on the Jones-Lee (1989) adjustment factor of 0.63, which yields a VSL of $2.3 million for populations over the age of 70. Deaths of individuals under the age of 70 are valued using the unadjusted mean VSL value of $3.7 million (1999$). Since these are acute mortalities, it is assumed that there is no lag between reduced exposure and reduced risk of mortality.

A simpler and potentially less biased approach is to simply apply a single age adjustment based on whether the individual was over or under 65 years of age at the time of death. This is consistent with the range of observed ages in the Jones-Lee studies and also agrees with the findings of more recent studies by Krupnick et al. (2000) that the only significant difference in WTP is between the over 70 and under 70 age groups. To correct for the potential extrapolation error for ages beyond 70, the adjustment factor is selected as the ratio of a 70 year old individual's WTP to a 40 year old individual's WTP, which is 0.63, based on the Jones-Lee (1989) results and 0.92 based on the Jones-Lee (1993) results.

The third issue is addressed in the Alternative Estimate by assuming that deaths from chronic obstructive pulmonary disease (COPD) are advanced by 6 months, and deaths from all other causes are advanced by 5 years. These reductions in life years lost are applied regardless of the age at death. Actuarial evidence suggests that individuals with serious preexisting cardiovascular conditions have a remaining life expectancy of around 5 years. While many deaths from daily exposure to PM may occur in individuals with cardiovascular disease, studies have shown relationships between all cause mortality and PM, and between PM and mortality from pneumonia (Schwartz, 2000). In addition, recent studies have shown a relationship between PM and non-fatal heart attacks, which suggests that some of the deaths due to PM may be due to fatal heart attacks (Peters et al., 2001). And, a recent meta-analysis has shown little effect of age on the relative risk from PM exposure (Stieb et al. 2002), which suggests that the number of deaths in non-elderly populations (and thus the potential for greater loss of life years) may be significant. Indeed, this analysis estimates that 21 percent of non-COPD premature deaths avoided are in populations under 65. Thus, while the assumption of 5 years of life lost may be appropriate for a subset of total avoided premature mortalities, it may over or underestimate the degree of life shortening attributable to PM for the remaining deaths.

In order to value the expected life years lost for COPD and non-COPD deaths, we need to construct estimates of the value of a statistical life year. The value of a life year varies based on the age at death, due to the differences in the base VSL between the 65 and older population and the under 65 population. The valuation approach used is a value of statistical life years (VSLY) approach, based on amortizing the base VSL for each age cohort. Previous applications have arrived at a single value per life year based on the discounted stream of values that correspond to the VSL for a 40 year old worker (U.S. EPA, 1999a). This assumes 35 years of life lost is the base value associated with the mean VSL value of $3.7 million (1999$). The VSLY associated with the $3.7 million VSL is $163,000, annualized assuming EPA's guideline value of a 3 percent discount rate, or $270,000, annualized assuming OMB's guideline value of a 7 percent discount rate.

The VSL applied in this analysis is then built up from that VSLY by taking the present value of the stream of life years, again assuming a 3% discount rate. Thus, if you assume that a 40 year-old dying from pneumonia would lose 5 years of life, the VSL applied to that death would be $0.79 million. For populations over age 65, we then develop a VSLY from the age-adjusted base VSL of $2.3 million. Given an assumed remaining life expectancy of 10 years, this gives a VSLY of $258,000, assuming a 3 percent discount rate. Again, the VSL is built based on the present value of 5 years of lost life, so in this case, we have a 70 year old individual dying from pneumonia losing 5 years of life, implying an estimated VSL of $1.25 million. COPD deaths for populations aged 65 and older are valued at $0.13 million per incidence. Finally, COPD deaths for populations aged 64 and younger are valued at $0.09 million per incidence. The implied VSL for younger populations is less than that for older populations because the value per life year is higher for older populations. Since we assume that there is a 5 year loss in life years for a PM related mortality, regardless of the age of person dying, this necessarily leads to a lower VSL for younger populations. As a final step, these estimated VSL values are multiplied by the appropriate adjustment factors to account for changes in WTP over time.

10.3.9.1 Alternative Calulations of Chronic Bronchitis Monetary Values

For the alternative estimate, a cost-of illness value is used in place of willingness-to-pay to reflect uncertainty about the value of reductions in incidences of chronic bronchitis. In the primary estimate, the willingness-to-pay estimate was derived from two contingent valuation studies (Viscusi et al., 1991; Krupnick and Cropper, 1992). These studies were experimental studies intended to examine new methodologies for eliciting values for morbidity endpoints. Although these studies were not specifically designed for policy analysis, the SAB (EPA-SAB-COUNCIL-ADV-00-002, 1999) has indicated that the severity-adjusted values from this study provide reasonable estimates of the WTP for avoidance of chronic bronchitis. As with other contingent valuation studies, the reliability of the WTP estimates depends on the methods used to obtain the WTP values. In order to investigate the impact of using the CV based WTP estimates, the alternative estimates rely on a value for incidence of chronic bronchitis using a cost-of-illness estimate based Cropper and Krupnick (1990) which calculates the present value of the lifetime expected costs associated with the illness. The current cost-of-illness (COI) estimate for chronic bronchitis is around $107,000 per case, compared with the current WTP estimate of $330,000. Because the alternative estimate is based on cost-of-illness, no income adjustments are applied when applying the estimate in future year analyses.

10.3.9.2 Alternative Calulations Results

Applying the techniques (including the C-R and valuation alternatives described above) to the estimated changes in NOx and direct PM emissions for Large SI engines from this rule yields estimates of the number of avoided incidences of premature mortalities and chronic bronchitis cases and the associated monetary values for those avoided incidences. These estimates are presented in Table 10.3-8 for 2030. All of the monetary benefits are in constant 2002 dollars.

Table 10.3-8.
Alternative Benefits in 2030 from PM-related Reductions from the Large SI Categories.

	Alternative Estimate Incidence[A]	Alternative Estimation Valuation[B] (million $)
Short-term exposure mortality	600	$810
Chronic bronchitis	640	$90

[A] Incidences are rounded to the nearest 10.
[B] Dollar values are rounded to the nearest $10 million.

In Table 10.3-9, we present the benefits over time as the regulations phase in over time and a net present value, assuming a 3 percent social discount rate.

Table 10.3-9
Alternative Monetized Benefits Mortality and Chronic Bronchitis for Large SI Category Only [A]

Year	Nox Reductions	PM Reductions	Total Benefits (thousands)	
2004	40,117	0	$	50,000
2005	74,541	0	$	90,000
2006	108,754	0	$	130,000
2007	152,431	0	$	190,000
2008	193,218	0	$	250,000
2009	233,094	0	$	300,000
2010	271,554	0	$	350,000
2011	306,016	0	$	440,000
2012	328,022	0	$	470,000
2013	347,920	0	$	510,000
2014	365,688	0	$	550,000
2015	378,511	0	$	570,000
2016	389,820	0	$	600,000
2017	400,470	0	$	620,000
2018	410,477	0	$	650,000
2019	419,931	0	$	670,000
2020	428,805	0	$	700,000
2021	437,527	-1	$	720,000
2022	446,085	-1	$	750,000
2023	454,549	-1	$	770,000
2024	462,994	-1	$	790,000
2025	471,382	-1	$	810,000
2026	479,206	-1	$	830,000
2027	486,998	-1	$	850,000
2028	494,665	-1	$	870,000
2029	502,188	-1	$	880,000
2030	509,684	-1	$	900,000
Net Present Value 2002 to 2030				$8,800 million

[A] This alternative analysis excludes the health effects we are not able to quantify for PM, ozone, CO, and HC as well as excluding benefits from long-term exposure mortality, hospital admissions, emergency department visits, upper and lower respiratory symptoms, asthma attacks, acute bronchitis, work loss days and minor restricted activity days. A detailed list is provided in Table 10.2-1. Only NOx and PM reductions from Large SI are quantified. The sizable PM and Nox reductions from ATVs, OHMs, snowmobiles, and recreational marine diesel are not quantified.
[B] Dollar values are rounded to the nearest $10 million.
[c] A social discount rate of 3 percent is used to calculate the net present value. If a discount rate of 7 percent is used, the net present value (2002 - 2030) is $4.57 billion.

10.4 CO and Air Toxics Health Benefits Estimation

Although we achieve substantial reductions in CO and HC (many of which are hazardous air pollutants), we are unable to quantify benefits for these reductions. We present two techniques for estimating the economic benefits of changes in emissions from snowmobiles that are possible areas for further reserach.

10.4.1 Direct Valuation of "Clean" Snowmobiles

In general, economists tend to view an individual's willingness-to-pay (WTP) for a improvement in environmental quality as the appropriate measure of the value of a risk reduction. An individual's willingness-to-accept (WTA) compensation for not receiving the improvement is also a valid measure. However, WTP is generally considered to be a more readily available and conservative measure of benefits. Adoption of WTP as the measure of value implies that the value of environmental quality improvements is dependent on the individual preferences of the affected population and that the existing distribution of income (ability to pay) is appropriate.

For many goods, WTP can be observed by examining actual market transactions. For example, if a gallon of bottled drinking water sells for one dollar, it can be observed that at least some persons are willing to pay one dollar for such water. For goods not exchanged in the market, such as most environmental "goods," valuation is not as straightforward. Nevertheless, a value may be inferred from observed behavior, such as sales and prices of products that result in similar effects or risk reductions, (e.g., non-toxic cleaners or safety devices). Alternatively, surveys may be used in an attempt to directly elicit WTP for an environmental improvement.

One distinction in environmental benefits estimation is between use values and non-use values. Although no general agreement exists among economists on a precise distinction between the two (see Freeman, 1993), the general nature of the difference is clear. Use values are those aspects of environmental quality that affect an individual's welfare more or less directly. These effects include changes in product prices, quality, and availability, changes in the quality of outdoor recreation and outdoor aesthetics, changes in health or life expectancy, and the costs of actions taken to avoid negative effects of environmental quality changes.

Non-use values are those for which an individual is willing to pay for reasons that do not relate to the direct use or enjoyment of any environmental benefit, but might relate to existence values and bequest values. Non-use values are not traded, directly or indirectly, in markets. For this reason, the measurement of non-use values has proved to be significantly more difficult than the measurement of use values. The air quality changes produced by the final Large SI/Recreational Vehicle rule cause changes in both use and non-use values, but the monetary benefit estimates are almost exclusively for use values.

The most direct way to measure the economic value of air quality changes is in cases where the endpoints have market prices. More frequently than not, the economic benefits from environmental quality changes are not traded in markets, so direct measurement techniques can not be used.

Estimating benefits for public land activities or its existence value is a more difficult and less precise exercise because the endpoints are not directly or indirectly valued in markets. For example, the loss of a species of animal or plant from a particular habitat does not have a well-defined price, neither does a crisp winter day of quietude. The contingent valuation (CV) method has been employed in the economics literature to value endpoint changes for both visibility and ecosystem functions (Chestnut and Dennis, 1997). There is an extensive scientific literature and body of practice on both the theory and technique of CV. EPA believes that well-designed and well-executed CV studies are valid for estimating the benefits of air quality regulation.[ww]

The contingent valuation (CV) method uses survey techniques to estimate values individuals place on goods and services for which no market exists. Contingent valuation has been widely applied (Mitchell and Carson 1989, and Walsh, Johnson, and McKean 1992), and the U.S. Water Resources Council recognizes this as an appropriate method. The U.S. Department of Interior's federal guidelines have designated CV as the best available procedure for valuing damages arising in Superfund natural resource damage cases (U.S. DOI 1986, 1991).

The CV method values endpoints by using carefully structured surveys to ask a sample of people what amount of compensation is equivalent to a given change in environmental quality. In a CV survey, individuals are asked about their willingness to pay for a given service or commodity contingent on their acceptance of a hypothetical but plausible and realistic market situation. Thus, there are three main elements in the approach: 1) a description of the commodity to be valued; 2) the payment vehicle (i.e., how the individual will pay for the good or service); and 3) the form of the question (e.g., open-ended or dichotomous choice questions). A study that

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[ww]Concerns about the reliability of value estimates from CV studies arose because research has shown that bias can be introduced easily into these studies if they are not carefully conducted. Accurately measuring WTP for avoided health and welfare losses depends on the reliability and validity of the data collected. There are several issues to consider when evaluating study quality, including but not limited to 1) whether the sample estimates of WTP are representative of the population WTP; 2) whether the good to be valued is comprehended and accepted by the respondent; 3) whether the WTP elicitation format is designed to minimize strategic responses; 4) whether WTP is sensitive to respondent familiarity with the good, to the size of the change in the good, and to income; 5) whether the estimates of WTP are broadly consistent with other estimates of WTP for similar goods; and 6) the extent to which WTP responses are consistent with established economic principles.

contained information about use value for “clean, quiet” snowmobiles was recently conducted (Duffield and Neher 2000).[xx] However, the study was judged to have limitations in its application here. The National Park Service is endeavoring to conduct a new study that may address the short-comings of this study.

10.4.2 Overview of Benefits Estimation for CO and Air Toxics from the Final Rule

A large variety of substances is emitted from tail pipes of snowmobiles powered by two-stroke engines.[1] Some of these substances may be acutely neurotoxic at sufficiently high concentration, including volatile hydrocarbons (HC) and carbon monoxide (CO). The acute neurotoxicity of only two of the identified exhaust components have been studied extensively on an individual basis (toluene and CO), but the combined toxicity of the mixture of toluene and CO has not been evaluated.[2] Toluene comprises about 20 percent of the total amount of hydrocarbons in the exhaust of snowmobiles.[3] As discussed above, up to a third of the fuel and lubricating oil mixture delivered to the 2-stroke snowmobile engine is emitted directly without being burned.

Ideally, we would have quantified the economic benefit of reductions in all of these pollutants from vehicles subject to our final rule. In developing a method to quantify economic benefits for the reduction of these toxic pollutants, however, we were limited by the available exposure literature to modeling a specific common exposure scenario for snowmobiles. After detailed subsequent investigation of the limited exposure information, we judge the study to contain too many unresolved uncertainties to be used in this analysis. Further, we are not able to quantify exposures related to other high-emitting 2-stroke engines in ATVs or OHMCs. Furthermore, there are substantial uncertainties in the analysis and gaps in our underlying knowledge. More research is needed, especially regarding exposure to neurotoxicants emitted from these and other categories of 2-stroke engines to facilitate benefits calculations.

If after further study, we learn that off-road vehicle operators are exposed to combined levels of neurotoxicants at levels that impair skills related to driving ability,[4] then reductions in these exposures could result in fewer accidents and avoided medical and property damage costs. However, we were limited by gaps in knowledge about exposure estimates and health effects related to most neurotoxic compounds. For air toxics and CO, it can be important to consider both momentary blood dose as well as longer term exposures in evaluating the health effects and monetary benefits.

[xx]Duffield, JW and CJ Neher. Winter 1998-99 Visitor Survey: Yellowstone National Park, Grand Teton National Park, and Greater Yellowstone Area. May 2000. Docket A-2000-01, Document IV-A-113. The survey instrument and the report were independently peer-reviewed.

10.5 Total Benefits

We provide our base-case estimate of benefits for each health and welfare endpoint as well as the resulting base-case estimate of total benefits. To obtain this estimate, we aggregate dollar benefits associated with each of the effects examined, such as hospital admissions, into a total benefits estimate assuming that none of the included health and welfare effects overlap. The base-case estimate of the total benefits associated with the health and welfare effects is the sum of the separate effects estimates. Total monetized benefits associated with the final Large SI/Recreational Vehicle rule are listed in Table 10.5-1, along with a breakdown of benefits for the Large SI category only by endpoint. Note that the value of endpoints known to be affected by ozone and/or PM that we are not able to monetize are assigned a placeholder value (e.g., B_1, B_2, etc.). Unquantified physical effects are indicated by a U. The estimate of total benefits is thus the sum of the monetized benefits and a constant, B, equal to the sum of the unmonetized benefits, $B_1+B_2+...+B_n$.

A comparison of the incidence column to the monetary benefits column reveals that there is not always a close correspondence between the number of incidences avoided for a given endpoint and the monetary value associated with that endpoint. For example, there many times more asthma attacks than premature mortalities, yet these asthma attacks account for only a very small fraction of total monetized benefits. This reflects the fact that many of the less severe health effects, while more common, are valued at a lower level than the more severe health effects. Also, some effects, such as asthma attacks, are valued using a proxy measure of WTP. As such the true value of these effects may be higher than that reported in Table 10.5-1.

Table 10.5-1
Base-Case Estimate of Annual Health Benefits Associated With Air Quality Changes Resulting from the Large SI/Recreational Vehicle Rule in 2030

Endpoint	Avoided Incidence[A] (cases/year)	Monetary Benefits[B] (millions 2002$, adjusted for growth in real income)
PM-related Endpoints[C]		
Premature mortality[D] (adults, 30 and over)	1,000	$7,510
Chronic bronchitis (adults, 26 and over)	640	$280
Hospital Admissions – Pneumonia (adults, over 64)[F]	100	<$5
Hospital Admissions – COPD (adults, 64 and over)	100	<$5
Hospital Admissions – Asthma (65 and younger)	100	<$1
Hospital Admissions – Cardiovascular (adults, over 64)	300	<$10
Emergency Room Visits for Asthma (65 and younger)	300	<$1
Asthma Attacks (asthmatics, all ages)[E]	20,600	<$1
Acute bronchitis (children, 8-12)	2,200	<$1
Lower respiratory symptoms (children, 7-14)	23,700	<$1
Upper respiratory symptoms (asthmatic children, 9-11)	23,400	<$1
Work loss days (adults, 18-65)	181,300	$20
Minor restricted activity days (adults, age 18-65)	944,400	$50
Other PM-related health effects[E]	U_1	B_1
Ozone-related Endpoints	U_2	B_2
Quantified HC-related WTP	--	U_3
CO and HC-related health effects[E]	U_4+U_5	B_3
Monetized Total Health-related Benefits[G]	—	$7,880 +$\mathbf{B_H}$

[A] Incidences are rounded to the nearest 100. Nox and PM-related reductions are not quantified for ATVs, OHMs, snowmobiles and recreational marine diesel.
[B] Dollar values are rounded to the nearest $10 million.
[C] PM-related benefits are based on the assumption that Eastern U.S. nitrate reductions are equal to one-fifth the nitrate reductions predicted by REMSAD (see HD07 RIA Chapter II for a discussion of REMSAD and model performance).
[D] Premature mortality associated with ozone is not separately included in this analysis (also note that the estimated value for PM-related premature mortality assumes the 5 year distributed lag structure).
[E] A detailed listing of unquantified PM, ozone, CO, and HC related health effects is provided in Table 10.2-1.
[F] Based upon recent preliminary findings by the Health Effects Institute, the concentration-response functions used to estimate reductions in hospital admissions may over- or under-estimate the true concentration-response relationship. Our examination of the original studies used in this analysis finds that the health endpoints that are potentially affected by the GAM issues include: reduced hospital admissions and reduced lower respiratory symptoms. While resolution of these issues is likely to take some time, the preliminary results from ongoing reanalyses of some of the studies suggest a more modest effect of the S-plus error than reported for the NMMAPS PM_{10} mortality study. While we wait for further clarification from the scientific community, we have chosen not to remove these results from the benefits estimates, nor have we elected to apply any interim adjustment factor based on the preliminary reanalyses. EPA will continue to monitor the progress of this concern, and make appropriate adjustments as further information is made available.
[G] $\mathbf{B_H}$ is equal to the sum of all unmonetized categories, i.e. B_a+B_1

10.6 Comparison of Costs to Benefits

Benefit-cost analysis provides a valuable framework for organizing and evaluating information on the effects of environmental programs. When used properly, benefit-cost analysis helps illuminate important potential effects of alternative policies and helps set priorities for closing information gaps and reducing uncertainty. According to economic theory, the efficient policy alternative maximizes net benefits to society (i.e., social benefits minus social costs). However, not all relevant costs and benefits can be captured in any analysis. Executive Order 12866 clearly indicates that unquantifiable or nonmonetizable categories of both costs and benefits should not be ignored. There are many important unquantified and unmonetized costs and benefits associated with reductions in emissions, including many health and welfare effects. Potential benefit categories that have not been quantified and monetized are listed in Table 10.2-1 of this chapter.

The estimated social cost (measured as changes in consumer and producer surplus) in 2030 to implement the final Large SI/Recreational Vehicle program from Chapter 9 is $216 million (2001$). The net social gain, considering fuel efficiency, is $553 million. The monetized benefits are approximately $7.8 billion, and EPA believes there is considerable value to the public of the benefits it could not monetize. The net benefit that can be monetized is $8.4 billion. Therefore, implementation of the Large SI/Recreational Vehicle program is expected to provide society with a net gain in social welfare based on economic efficiency criteria. Table 10.6-1 summarizes the costs, benefits, and net benefits.

Table 10.6-1

	Millions of 2001$[a]
Social Gains	$550
Monetized PM-related benefits[b,c]	$7,880 + $\mathbf{B_{PM}}$
Monetized Ozone-related benefits[b,d]	not monetized ($\mathbf{B_{Ozone}}$)
HC-related benefits	not monetized ($\mathbf{B_{HC}}$)
CO-related benefits	not monetized ($\mathbf{B_{CO}}$)
Total annual benefits	$7,880 +$\mathbf{B_{PM}}$ + $\mathbf{B_{Ozone}}$ + $\mathbf{B_{HC}}$ + $\mathbf{B_{CO}}$
Monetized net benefits[e]	$8,430 + **B**

[a] For this section, all costs and benefits are rounded to the nearest 10 million. Thus, figures presented in this chapter may not exactly equal benefit and cost numbers presented in earlier sections of the chapter.
[b] Not all possible benefits or disbenefits are quantified and monetized in this analysis. Potential benefit categories that have not been quantified and monetized are listed in Table IX-E.2**.** Unmonetized PM- and ozone-related benefits are indicated by B_{PM}. And B_{Ozone}, respectively.
[c] Based upon recent preliminary findings by the Health Effects Institute, the concentration-response functions used to estimate reductions in hospital admissions may over- or under-estimate the true concentration-response relationship.
[d]There are substantial uncertainties associated with the benefit estimates presented here, as compared to other EPA analyses that are supported by specific modeling. This analysis used a benefits transfer technique described in the RSD.
[e] **B** is equal to the sum of all unmonetized benefits, including those associated with PM, ozone, CO, and HC.

The net present value of the future benefits has also been calculated, using a 3 percent discount rate over the 2002 to 2030 time frame. The net present value of the social gains, from Table 9.1-7 of Chapter 9, is $4,930 million. The net present value of the total annual benefits, from Tables 10.3-7 and 10.4-3, is $77,177 million + B. Consequently, the net present value of the monetized net benefits of this program is $82,107 million.

For each of the vehicle categories, the net present value of the future streams of surplus losses, fuel savings, social costs/gains, health and environmental benefits and net cost/benefits have been calculated. The net present values of these future streams are calculated using a 3 percent discount rate (in Chapters 9, 10, and 11) and are calculated over the 2002 to 2030 time frame.

These net present value estimates are sensitive to the discount rate. Table 10.6-2 presents an alternative net present value calculation of the surplus loss, fuel savings, social costs/gains, health and environmental benefits, and net cost or benefits for the control programs being adopted in this rulemaking, for each vehicle category, for the period 2002 to 2030, assuming an alternative discount rate of 7%.

Table 10.6-2
Net Present Values*, Fuel Cost Savings, and Social Costs/Gains
(millions of 2001$)**

Vehicle Category	NPV of Surplus Loss	NPV of Fuel Cost Savings	NPV of Social Costs/Gains ***
CI Marine	$59.0	$0.0	$59.0
Forklifts	$415.8	$2,644.2	($2,228.4)
Other Large SI****	$419.7	$804.8	($385.1)
Snowmobiles	$296.9	$459.7	($162.8)
ATVs	$491.9	$253.0	$238.9
Off-Highway Motorcycles	$206.2	$120.6	$85.6
Total	**$1,889.5**	**$4,282.3**	**($2,392.8)**

* Net Present Values are calculated using a discount rate of 7 percent over the 2002 - 2030 time period.
** Figures are in year 2000 and 2001 dollars, depending on the vehicle category; ( ) represents a negative cost (social gain).
***Figures in this column exclude estimated health and environmental benefits.
****Figures in this row are engineering cost estimates. See Section 9.7.6 of Chapter 9.

The net present value of the future benefits has also been calculated, using a 7 percent discount rate over the 2002 to 2030 time frame. The net present value of the social gains from above, is $2,393 million. The net present value of the total annual health and environmental benefits that we were able to quantify using a 7 percent discount rate is $40,070 million + B. Consequently, the net present value of the monetized net benefits of this program using a 7 percent discount rate is $42,477 + B million.

Chapter 10 Bibliography

Abbey, D.E., B.L. Hwang, R.J. Burchette, T. Vancuren, and P.K. Mills. 1995a. “Estimated Long-Term Ambient Concentrations of PM(10) and Development of Respiratory Symptoms in a Nonsmoking Population.” *Archives of Environmental Health* 50(2): 139-152.

Abbey, D.E., F. Petersen, P. K. Mills, and W. L. Beeson. 1993. “Long-Term Ambient Concentrations of Total Suspended Particulates, Ozone, and Sulfur Dioxide and Respiratory Symptoms in a Nonsmoking Population.” *Archives of Environmental Health* 48(1): 33-46.

Abt Associates Inc., 2000.. *Heavy Duty Engine/Diesel Fuel Rule: Air Quality Estimation, Selected Health and Welfare Benefits Methods, and Benefit Analysis Results*. Prepared for US EPA, Office of Air Quality Planning and Standards. Research Triangle Park, NC. November. A copy of this document can be found in Docket A-2000-01, Document IV-A-219.

Abt Associates, Inc., 1999a. *Tier2 Final Rule: Air Quality Estimation, Selected Health and Welfare Benefits Methods, and Benefit Analysis Results,* Prepared for the US Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, November.

Abt Associates Inc., 1999b. Memorandum to Lisa Conner, US EPA, Office of Air Quality Planning and Standards. “Derivation of 2030 Population Estimates for the Tier II Analysis.” September.

Abt Associates Inc., 1998. *Air Quality Estimation for the NOx SIP Call RIA*. Prepared for US EPA, Office of Air Quality Planning and Standards, under contract no. 68-D-98-001. Research Triangle Park, NC. September. See EPA Air Docket A-96-56, Document No. VI-B-09.

American Lung Association, 1999. Chronic Bronchitis. Web site available at: http://www.lungusa.org/diseases/lungchronic.html.

Blumenschein, K. and M. Johannesson. 1998. “Relationship Between Quality of Life Instruments, Health State Utilities, and Willingness to Pay in Patients with Asthma.” *Annals of Allergy, Asthma, and Immunology* 80:189-194.

Benignus, V, W Boyes, and P. Bushnell, US Environmental Protection Agency. National Health and Environmental Effects Research Laboratory. Memorandum to the Docket. Acute Behavioral Effects of Exposure to Toluene and Carbon Monoxide from Snowmobile Exhaust. September 2002. A copy of this document can be found in Docket A-2000-01, Document IV-A-143.

Chestnut, L.G. 1997. Draft Memorandum: *Methodology for Estimating Values for Changes in*

Visibility at National Parks. April 15.

Chestnut, L.G. and R.L. Dennis. 1997. Economic Benefits of Improvements in Visibility: Acid Rain Provisions of the 1990 Clean Air Act Amendments. *Journal of Air and Waste Management Association* 47:395-402.

Chestnut, L.G., and R.D. Rowe. 1990b. A New National Park Visibility Value Estimates. In *Visibility and Fine Particles*, Transactions of an AWMA/EPA International Specialty Conference, C.V. Mathai, ed. Air and Waste Management Association, Pittsburgh.

Chestnut, L.G. and R.D. Rowe. 1990a. *Preservation Values for Visibility Protection at the National Parks: Draft Final Report.* Prepared for Office of Air Quality Planning and Standards, US Environmental Protection Agency, Research Triangle Park, NC and Air Quality Management Division, National Park Service, Denver, CO.

Crocker T. D. and R. L. Horst, Jr. 1981. "Hours of Work, Labor Productivity, and Environmental Conditions: a Case Study." *The Review of Economics and Statistics* 63:361-368.

Delfino, R.J., R.S. Zeiger, J.M. Seltzer, and D.H. Street. 1998. Symptoms in Pediatric Asthmatics and Air Pollution: Differences in Effects by Symptom Severity, Anti-inflammatory Medication Use and Particulate Averaging Time. *Environmental Health Perspectives*, 106(11): 751-761.

Delfino, R.J., R.S. Zeiger, J.M. Seltzer, and D.H. Street, 1998. Symptoms in Pediatric Asthmatics and Air Pollution: Differences in Effects by Symptom Severity. Anti-inflammatory Medication Use and Particulate Averaging Time. *Environmental Health Perspectives*, 106(11): 751-761.

Dennis, R.L., 1997. "Using the Regional Acid Deposition Model to Determine the Nitrogen Deposition Airshed of the Chesapeake Bay Watershed." In: *Atmospheric Deposition to the Great Lakes and Coastal Waters*. Baker, J.E., ed. Society of Environmental Toxicology and Chemistry, Pensacola, FL. pp. 393-413. See EPA Air Docket A-96-56, Document No. VI-B-09.

Desvouges, W.H., F. R. Johnson, and H.S. Banzhaf. 1998. *Environmental Policy Analysis with Limited Information: Principles and Applications of the Transfer Method*. Edward Elgar, Northhampton, MA.

Dickie, M. et al. 1991. Reconciling Averting Behavior and Contingent Valuation Benefit Estimates of Reducing Symptoms of Ozone Exposure (draft), as cited in Neumann, J.E., Dickie, M.T., and R.E. Unsworth. 1994. Industrial Economics, Incorporated. Memorandum to Jim DeMocker, US EPA, Office of Air and Radiation. March 31.

Dillman, D. 1992. Mail and Telephone Surveys. John Wiley Publishing. New York.

Dockery, D.W., C.A. Pope, X.P. Xu, J.D. Spengler, J.H. Ware, M.E. Fay, B.G. Ferris and F.E. Speizer. 1993. "An association between air pollution and mortality in six U.S. cities." *New England Journal of Medicine* 329(24): 1753-1759.

Dockery, D.W., J. Cunningham, A.I. Damokosh, L.M. Neas, J.D. Spengler, P. Koutrakis, J.H. Ware, M. Raizenne and F.E. Speizer. 1996. "Health Effects of Acid Aerosols On North American Children-Respiratory Symptoms." *Environmental Health Perspectives*. 104(5): 500-505.

Douglas, S.G. and R.K. Iwamiya, 1999. *Estimating the Effects of the Tier 2 Motor-Vehicle Standards on Air Quality: Ozone*. Prepared for Abt Associates, Inc. Prepared by Systems Applications International, Inc. SYSAPP-99-98/50. January.

Duffield, J.W., Neher, C. J. Winter 1998-99 Visitor Survey Yellowstone N.P., Grand Teton N.P., and the Greater Yellowstone Area Final Report. Report prepared for National Park Service, Denver, CO. May, 2000. This document is available in Docket A-2000-01, Document IV-A-114.

E.H. Pechan & Associates, 1996. R*egional Particulate Control Strategies Phase II*. Prepared for the US Environmental Protection Agency, Office of Policy, Planning, and Evaluation. Washington, DC. September.

E.H. Pechan & Associates, 1999. *Emissions and Air Quality Impacts of Proposed Motor Vehicle Tier 2 and Fuel Sulfur Standards*. Prepared by The Pechan-Avanti Group under EPA Contract No. 68-D9-8052. for US EPA, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group. Research Triangle Park, NC. January.

Elixhauser, A., R.M. Andrews, and S. Fox. 1993. Clinical Classifications for Health Policy Research: Discharge Statistics by Principal Diagnosis and Procedure. Agency for Health Care Policy and Research (AHCPR), Center for General Health Services Intramural Research, US Department of Health and Human Services.

Empire State Electric Energy Research Corporation (ESEERCO). 1994. *New York State Environmental Externalities Cost Study. Report 2: Methodology*. Prepared by: RCG/Hagler, Bailly, Inc., November.

EPA-SAB, Health and Ecological Effects Subcommittee of the Advisory Council on Clean Air Act Compliance Analysis. 1999. Summary Minutes of Public Meeting, April 21-22, 1999.

EPA-SAB-COUNCIL-ADV-99-05, 1999. An SAB Advisory on the Health and Ecological

Effects Initial Studies of the Section 812 Prospective Study: Report to Congress: Advisory by the Health and Ecological Effects Subcommittee, February.

EPA-SAB-COUNCIL-ADV-98-003, 1998. Advisory Council on Clean Air Compliance Analysis Advisory on the Clean Air Act Amendments (CAAA) of 1990 Section 812 Prospective Study: Overview of Air Quality and Emissions Estimates: Modeling, Health and Ecological Valuation Issues Initial Studies.

EPA-SAB-COUNCIL-ADV-99-012, 1999. The Clean Air Act Amendments (CAAA) Section 812 Prospective Study of Costs and Benefits (1999): Advisory by the Health and Ecological Effects Subcommittee on Initial Assessments of Health and Ecological Effects: Part 1. July. A copy of this document can be found in Docket A-2000-01, Document IV-A-204.

EPA-SAB-COUNCIL-ADV-00-001, 1999. The Clean Air Act Amendments (CAAA) Section 812 Prospective Study of Costs and Benefits (1999): Advisory by the Health and Ecological Effects Subcommittee on Initial Assessments of Health and Ecological Effects: Part 2. October, 1999.

EPA-SAB-COUNCIL-ADV-00-002, 1999. The Clean Air Act Amendments (CAAA) Section 812 Prospective Study of Costs and Benefits (1999): Advisory by the Advisory Council on Clean Air Compliance Analysis: Costs and Benefits of the CAAA. Effects Subcommittee on Initial Assessments of Health and Ecological Effects: Part 2. October, 1999.

EPA-SAB-EEAC-00-013, 2000. An SAB Report on EPA's White Paper *Valuing the Benefits of Fatal Cancer Risk Reduction*.US Environmental Protection Agency, Science Advisory Board, Environmental Economics Advisory Committee, July 27, 2000. A copy of this document can be found in Docket A-99-06, Document IV-A-19.

Greenbaum, D., President, Health Effects Institute. "Dear Colleague" letter dated May 30, 2002. A copy of this letter can be found in Docket A-2000-01, Document IV-A-145, as an attachment to a letter from Lester D. Grant, PhD, to Dr. Philip K. Hopke, dated August 8, 2002.

Grosclaude, P. and N.C. Soguel. 1994. "Valuing Damage to Historic Buildings Using a Contingent Market: A Case Study of Road Traffic Externalities." *Journal of Environmental Planning and Management* 37: 279-287.

Holland, M., D. Forster, and M. Wenborn. 1999. Economic Evaluation of Proposals Under the UNECE Multi-effects and Multi-pollutant Protocol. Prepared for: European Commission, DGXI, Brussels and Luxembourg. January. Report no. AEAT-4587.

Hoskins, G., C. McCowan, R.G. Neville, G.E. Thomas, B. Smith, and S. Silverman. 2000. "Risk Factors and Costs Associated with and Asthma Attack." *Thorax*. 55: 19-24.

Hoskins, G., C. McCowan, R.G. Neville, G.E. Thomas, B. Smith, S. Silverman. 2000. Risk Factors and Costs Associated with an Asthma Attack. *Thorax*, 55: 19-24.

Hubbell, Bryan. 2002a. Senior Economist, OAQPS. Memorandum to Docket A-2000-01. Estimated NOx, SO2, and PM Emissions Health Damages for Heavy Duty Vehicle Emissions. April 22, 2002. A copy of this document can be found in Docket A-2000-01, Document IV-A-146.

Hubbell, Bryan. 2002b. Senior Economist, OAQPS. Memorandum to Trish Koman, OTAQ. Appendix to April 22 Memo "Estimated NOx, SO2, and PM Emissions Health Damages for Heavy Duty Vehicle Emissions": Alternative Estimates of Mortality and Chronic Bronchitis Impacts. A copy of this document can be found in Docket A-2000-01, Document IV-A-202.

Industrial Economics, Incorporated (IEc). 1994. Memorandum to Jim DeMocker, Office of Air and Radiation, Office of Policy Analysis and Review, US Environmental Protection Agency, March 31.

Jack, E., L.P. Boss, and W.M. Millington. 2000. Asthma - A Speaker's Kit for Public Health Professionals. Centers for Disease Control and Prevention, National Center for Health Statistics, Division of Environmental Hazards and Health Effects, Air Pollution and Respiratory Health Branch. Available at: http://www.cdc.gov/nceh/asthma/speakit/cover.htm.

Jones-Lee, M.W. 1989. *The Economics of Safety and Physical Risk*. Oxford: Basil Blackwell.

Jones-Lee, M.W., G. Loomes, D. O'Reilly, and P.R. Phillips. 1993. The Value of Preventing Non-fatal Road Injuries: Findings of a Willingness-to-pay National Sample Survey. TRY Working Paper, WP SRC2.

Krewski D, Burnett RT, Goldbert MS, Hoover K, Siemiatycki J, Jerrett M, Abrahamowicz M, White WH. 2000. Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality. Special Report to the Health Effects Institute, Cambridge MA, July 2000. A copy of this document can be found in Docket A-99-06, Document IV-G-75.

Krupnick, A.J., W. Harrington and B. Ostro. 1990. "Ambient Ozone and Acute Health Effects - Evidence From Daily Data." *Journal of Environmental Economics and Management* 18(1): 1-18.

Krupnick, A.J. and M.L. Cropper. 1992. "The Effect of Information on Health Risk Valuations." *Journal of Risk and Uncertainty* 5(2): 29-48.

Krupnick, A.J., A. Alberini, M. Cropper, N. Simon, B. O'Brien, R. Goeree, and M. Heintzelman. 2000. Age, Health, and the Willingness to Pay for Mortality Risk Reductions: A Contingent

Valuation Survey of Ontario Residents. Resources for the Future Discussion Paper 00-37.

Krupnick, A.J. 2000. Personal Communication, December 5.

Kunzli, N., R. Kaiser, S. Medina, M. Studnicka, O. Chanel, P. Filliger, M. Herry, F. Horak Jr., V. Puybonnieux-Texier, P. Quenel, J. Schneider, R. Seethaler, J-C Vergnaud, and H. Sommer. 2000. Public-health Impact of Outdoor and Traffic-related Air Pollution: A European Assessment. *The Lancet*, 356: 795-801.

Lang, C., G. Yarwood, F. Lalonde, and R. Bloxam. 1995. *Environmental and Health Benefits of Cleaner Vehicles and Fuels*. Prepared for: Canadian Council of Ministers of the Environment Task Force on Cleaner Vehicles and Fuels, Winnipeg, Manitoba. October.

Laurence, J.A., W.A. Retzlaff, J.S. Kern, E.H.Lee, W.E. Hogsett, and D.A. Weinstein. 2000. Predicting the regional impact of ozone and precipitation on the growth of loblolly pine and yellow-poplar using linked TREGRO and ZELIG models. For Ecological Management. In press.

Loehman, E.T., S.V. Berg, A.A. Arroyo, R.A. Hedinger, J.M. Schwartz, M.E. Shaw, R.W. Fahien, V.H. De, R.P. Fishe, D.E. Rio, W.F. Rossley, and A.E.S. Green. 1979. "Distributional Analysis of Regional Benefits and Cost of Air Quality Control." *Journal of Environmental Economics and Management* 6: 222-243.

Manuel, E.H., R.L. Horst, K.M. Brennan, W.N. Lanen, M.C. Duff and J.K. Tapiero. 1982. *Benefits Analysis of Alternative Secondary National Ambient Air Quality Standards for Sulfur Dioxide and Total Suspended Particulates, Volumes I-IV*. Prepared for US Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

McClelland, G., W. Schulze, D. Waldman, J. Irwin, D. Schenk, T. Stewart, L. Deck, and M. Thayer. 1993. *Valuing Eastern Visibility: A Field Test of the Contingent Valuation Method*. Prepared for Office of Policy, Planning and Evaluation, US Environmental Protection Agency. September.

McConnell, R., K. Berhane, F. Gilliland, S.J. London, H. Vora, E. Avol, W.J. Gauderman, H.G. Margolis, F. Lurmann, D.C. Thomas, and J.M. Peters. 1999. Air Pollution and Bronchitic Symptoms in Southern California Children with Asthma. *Environmental Health Perspectives*, 107(9): 757-760.

McConnell, R., K. Berhane, F. Gilliland, S.J. London, H. Vora, E. Avol, W.J. Gauderman, H.G. Margolis, F. Lurmann, D.C. Thomas, and J.M. Peters. 1999. Air Pollution and Bronchitic Symptoms in Southern California Children with Asthma. *Environmental Health Perspec*tives. 107(9): 757-760.

McDonnell, W.F., D.E. Abbey, N. Nishino and M.D. Lebowitz. 1999. "Long-term ambient ozone concentration and the incidence of asthma in nonsmoking adults: the ahsmog study." *Environmental Research*. 80(2 Pt 1): 110-21.

Mitchell, RC and RT Carson, 1989. Using Surveys to Value Public Goods: the Contingent Valuation Method. Resources for the Future. Washing ton DC.

NCLAN. 1988. Assessment of Crop Loss from Air Pollutants. (Eds. Walter W. Heck, O. Clifton Taylor and David T. Tingey) Elsevier Science Publishing Co.: New York, Pp. 1-5. (ERL,GB 639).

O'Conor, Richard M. and Glenn C. Blomquist, 1997. "Measurement of Consumer-Patient Preferences Using a Hybrid Contingent Valuation Method." *Journal of Health Economics* 16:667-683.

Ostro, B.D., M.J. Lipsett, J.K. Mann, H. Braxton-Owens, M.C. White, 1995. Air Pollution and Asthma Exacerbations Among African-American Children in Los Angeles. *Inhalation Toxicology*, 7:711-722.

Ostro, B.D. 1987. Air Pollution and Morbidity Revisited: a Specification Test. *Journal of Environmental Economics Management.* 14: 87-98.

Ostro B.D. and S. Rothschild. 1989. "Air Pollution and Acute Respiratory Morbidity: An Observational Study of Multiple Pollutants." *Environmental Research* 50:238-247.

Ostro, B.D., M.J. Lipsett, J.K. Mann, H. Braxton-Owens, M.C. White. 1995. Air Pollution and Asthma Exacerbations Among African-American Children in Los Angeles. *Inhalation Toxicology*, 7:711-722.

Pew Environmental Health Commission. 2000. *Attack Asthma: Why America Needs A Public Health Defense System to Battle Environmental Threats*. Johns Hopkins School of Public Health, Baltimore, MD.

Pew Environmental Health Commission. 2000. *Attack Asthma: Why America Needs A Public Health Defense System to Battle Environmental Threats.* John Hopkins School of Public Health, Baltimore, MD.

Pope, C.A., III, M.J. Thun, M.M. Namboodiri, D.W. Dockery, J.S. Evans, F.E. Speizer, and C.W. Heath, Jr. 1995. "Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults." *American Journal of Respiratory Critical Care Medicine* 151: 669-674.

Pope, C.A., III, D.W. Dockery, J.D. Spengler, and M.E. Raizenne. 1991. "Respiratory Health and PM_{10} Pollution: a Daily Time Series Analysis" *American Review of Respiratory Diseases* 144: 668-674.

Rowe, R.D. and L.G. Chestnut. 1986. "Oxidants and Asthmatics in Los Angeles: A Benefits Analysis--Executive Summary." Prepared by Energy and Resource Consultants, Inc. Report to the US EPA, Office of Policy Analysis. EPA-230-09-86-018. Washington, DC March.

Samet JM, Zeger SL, Dominici F, Curriero F, Coursac I, Dockery DW, Schwartz J, Zanobetti A. 2000. The National Morbidity, Mortality and Air Pollution Study: Part II: Morbidity, Mortality and Air Pollution in the United States. Research Report No. 94, Part II. Health Effects Institute, Cambridge MA, June 2000. Docket A-2000-01, Documents IV-A-205 and 206.

Schwartz, J., Dockery, D.W., Neas, L.M., Wypij, D., Ware, J.H., Spengler, J.D., Koutrakis, P., Speizer, F.E., and Ferris, Jr., B.G. 1994. "Acute Effects of Summer Air Pollution on Respiratory Symptom Reporting in Children" *American Journal of Respiratory Critical Care* Medicine 150: 1234-1242.

Schwartz, J. 1993. "Particulate Air Pollution and Chronic Respiratory Disease" *Environmental Research* 62: 7-13.

Sheppard, L., D. Levy, G. Norris, T.V. Larson and J.Q. Koenig. 1999. Effects of ambient air pollution on nonelderly asthma hospital admissions in Seattle, Washington, 1987-1994. *Epidemiology*. Vol. 10(1): 23-30.

Sisler, J.F. 1996. Spatial and Seasonal Patterns and Long Term Variability of the Composition of the Haze in the United States: An Analysis of Data from the IMPROVE Network. Cooperative Institute for Research in the Atmosphere, Colorado State University; Fort Collins, CO July.

Smith, D.H., D.C. Malone, K.A. Lawson, L. J. Okamoto, C. Battista, and W.B. Saunders, 1997. "A National Estimate of the Economic Costs of Asthma." *American Journal of Respiratory Critical Care Medicine* 156: 787-793.

Smith, V.K., G.Van Houtven, and S. Pattanayak. 1999. "Benefit Transfer as Preference Calibration" *Resources for the Future Discussion Paper* 99-36.

Taylor, C.R., K.H. Reichelderfer, and S.R. Johnson. 1993. Agricultural Sector Models for the United States: Descriptions and Selected Policy Applications. Iowa State University Press: Ames, IA.

Thurston, G.D., M.L. Lippman, M.B. Scott, and J.M. Fine. 1997. Summertime Haze Air Pollution and Children with Asthma. *American Journal of Respiratory Critical Care Medicine,* 155: 654-660.

Thurston, G.D., M.L. Lippman, M.B. Scott, and J.M. Fine. 1997. Summertime Haze Air Pollution and Children with Asthma. *American Journal of Respiratory Critical Care Medicine*, 155: 654-660.

Tolley, G.S. et al. 1986. Valuation of Reductions in Human Health Symptoms and Risks. University of Chicago. Final Report for the US Environmental Protection Agency. January.

US Department of Commerce, Economics and Statistics Administration. 1992. Statistical Abstract of the United States, 1992: The National Data Book. 112th Edition, Washington, DC.

US Department of Commerce, Bureau of Economic Analysis. 1995. BEA Regional Projections to 2045: Vol. 1, States. Washington, DC US Govt. Printing Office, July 1995.

US Department of Health and Human Services, Centers for Disease Control and Prevention. 1999. National Center for Environmental Health Web Site. Available at http://www.cdc.gov/nceh/asthma/factsheets/asthma.htm

US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics. 1994. Vital Statistics of the United States, 1990. Volume II-Mortality. Hyattsville, MD.

US Department of Health and Human Services, Centers for Disease Control and Prevention. 1999. "Forecasted State-Specific Estimates of Self-Reported Asthma Prevalence -- United States, 1998." *CDC-Morbidity and Mortality Weekly Report*, 47: 1022-1025.

US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics. 1999. National Vital Statistics Reports, 47(19).

US Department of Interior, 1986. Natural Resources Damage Assessment Rules and Regulations. (51 FR 148: 27725-27753. August 1, 1986)

US Department of Interior, 1991. Natural Resource Damage Assessment: Notice of Proposed Rulemaking. 56 FR 82: 19752-19753 April 29, 1991).

US Environmental Protection Agency, 1996b. *Review of the National Ambient Air Quality Standards for Particulate Matter: Assessment of Scientific and Technical Information.* Office of Air Quality Planning and Standards, Research Triangle Park, NC EPA report no. EPA/4521R-96-013. A copy of this document can be found in Docket A-99-06, Document II-A-23.

US Environmental Protection Agency, 1997e. *Regulatory Impact Analyses for the Particulate Matter and Ozone National Ambient Air Quality Standards and Proposed Regional Haze Rule.* US EPA, Office of Air Quality Planning and Standards. Research Triangle Park, NC. July. See

EPA Air Docket A-96-56, Document No. VI-B-09.

US Environmental Protection Agency, 1998a. *Regulatory Impact Analysis for the NOx SIP Call, FIP and Section 126 Petitions, Volume 2: Health and Welfare Benefits*. Prepared by: Innovative Strategies and Economics Group, Office of Air Quality Planning and Standards, Research Triangle Park, NC December.

US Environmental Protection Agency, 1997a. *Regulatory Impact Analysis for Particulate Matter and Ozone National Ambient Air Quality Standards and Proposed RH Rule.* Prepared by: Innovative Strategies and Economics Group, Office of Air Quality Planning and Standards, Research Triangle Park, NC. July.

US Environmental Protection Agency, 1998a. *Regulatory Impact Analysis for the NOx SIP Call, FIP, and Section 126 Petitions*. US EPA, Office of Air and Radiation. Washington, DC. EPA-452/R-98-003. December. See EPA Air Docket A-96-56, VI-B-09.

US Environmental Protection Agency, 1998b. *The Regional NOx SIP Call & Reduced Atmospheric Deposition of Nitrogen: Benefits to Selected Estuaries,* September.

US Environmental Protection Agency, 1999a. *The Benefits and Costs of the Clean Air Act, 1990-2010.* Prepared for US Congress by US EPA, Office of Air and Radiation/Office of Policy Analysis and Review, Washington, DC, November; EPA report no. EPA-410-R-99-001.

US Environmental Protection Agency, 1999b. *Regulatory Impact Analysis: Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements*. Prepared by: Office of Mobile Sources, Office of Air and Radiation, December.

US Environmental Protection Agency, 1999c. *Regulatory Impact Analysis for the Final Regional Haze Rule.* Office of Air Quality Planning and Standards, Research Triangle Park, NC. April 22, 1999.

US Environmental Protection Agency, 1997f. "Response to Comments Made by AISI on EPA Methodology for Predicting PM2.5 from PM10." Memorandum to the docket from Terence Fitz-Simons (Office of Air Quality Planning and Standards, Air Quality Trends Analysis Group). February 6. See EPA Air Docket A-96-56, Document No. VI-B-09.

US Environmental Protection Agency, 1996a. *Proposed Methodology for Predicting PM2.5 from PM10 Values to Assess the Impact of Alternative Forms and Levels of the PM NAAQS*. Prepared by Terence Fitz-Simons, David Mintz and Miki Wayland (US Environmental Protection Agency, Office of Air Quality Planning and Standard, Air Quality Trends Analysis Group). June 26. See EPA Air Docket A-96-56, Document No. VI-B-09.

US Environmental Protection Agency, 1996b. *Review of the National Ambient Air Quality Standards for Ozone: Assessment of Scientific and Technical Information.* Office of Air Quality Planning and Standards, Research Triangle Park, NC EPA report no. EPA/4521R-96-007. Docket A-99-06, Document II-A-22.

US Environmental Protection Agency, 1994. Documentation for Oz-One Computer Model (Version 2.0). Prepared by Mathtech, Inc., under Contract No. 68D30030, WA 1-29. Prepared for US EPA, Office of Air Quality Planning and Standards. Research Triangle Park, NC. August

US Environmental Protection Agency, 1993. External Draft, Air Quality Criteria for Ozone and Related Photochemical Oxidants. Volume II. US EPA, Office of Health and Environmental Assessment. Research Triangle Park, NC, EPA/600/AP-93/004b.3v.

US Environmental Protection Agency, 1999b. *Regulatory Impact Analysis for the Final Regional Haze Rule*. Prepared by: Office of Air Quality Planning and Standards, Office of Air and Radiation, April.

US Environmental Protection Agency, 2000a. Technical Support Document for the Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements- Air Quality Modeling Analyses. December 2000.

US Environmental Protection Agency, 2000b. *Valuing Fatal Cancer Risk Reductions*. White Paper for Review by the EPA Science Advisory Board.

US Environmental Protection Agency,1997c. "Methodology Used to Create PM10 and PM2.5 Air Quality Databases for RIA Work." Memorandum from David Mintz, Air Quality Trends Analysis Group, Office of Air Quality Planning and Standards to Allyson Siwik, Innovative Strategies and Economics Group, Office of Air Quality Planning and Standards. July 15. See EPA Air Docket A-96-56, Document No. VI-B-09.

US Environmental Protection Agency, 1997b. *The Benefits and Costs of the Clean Air Act, 1970 to 1990*. Prepared for US Congress by US EPA, Office of Air and Radiation/Office of Policy Analysis and Review, Washington, DC

U.S. EPA Guidelines for the Health Risk Assessment of Chemical Mixtures. EPA Report No. 630/R-98/002. September 24, 1986. Federal Register 51(185) : 34014 - 34025. http://cfpub.epa.gov/ncea/

Valigura, Richard A., and W.T. Luke, R.S. Artz, B.B. Hicks. 1996. Atmospheric input to coastal areas: reducing the uncertainties. NOAA Coastal Ocean Program, Decision Analysis Series No. 9. NOAA Atmospheric Resources Laboratory, Silver Spring, MD.

Valiela, G. Collins, and J. Kremer, K. Lajtha, M. Geist, B. Seely, J. Brawley, C.H. Sham. 1997. "Nitrogen loading from coastal watersheds to receiving estuaries: new method and application." *Ecological Applications* 7(2), pp. 358-380.

Viscusi, W.K. 1992. *Fatal Tradeoffs: Public and Private Responsibilities for Risk*. (New York: Oxford University Press).

Viscusi, W.K., W.A. Magat, and J. Huber. 1991. "Pricing Environmental Health Risks: Survey Assessments of Risk-Risk and Risk-Dollar Trade-Offs for Chronic Bronchitis" *Journal of Environmental Economics and Management*, 21: 32-51.

Walsh, RG, DM Johnson and JR McKean, 1992. Benefits Transfer of Outdoor Recreation Demand Studies, 1968 - 1988. Water Resource Research. 28: 703-713.

White, JJ and Carroll, JN. (1998) Emissions from snowmobile engines using bio-based fuels and lubricants. Final Report. Prepared for State of Montana Department of Environmental Quality. Southwest Research Institute report #7383.

Whittemore, A.S. and E.L. Korn. 1980. Asthma and Air Pollution in the Los Angeles Area. *Am J Public Health*. Vol. 70: 687-696.

Yu, O., L. Sheppard, T. Lumley, J. Q. Koenig, and G.G. Shapiro. 2000. Effects of Ambient Air Pollution on Symptoms of Asthma in Seattle-Area Children Enrolled in the CAMP Study. *Environmental Health Perspectives*, 108(12): 1209-1214.

Chapter 11: Regulatory Alternatives

Adopting standards to reduce emissions requires consideration of a variety of alternative approaches. This rulemaking development effort includes consideration of the timing of emission standards, the level of stringency, the appropriate test procedures, among other things. In this chapter, we present a variety of alternatives that we considered in preparing this rulemaking. While these alternatives were not adopted as part of the final rule, they are discussed here with an analysis of the associated costs and emission reductions involved and our rationale for not adopting them.

11.1 Recreational Marine Diesel Engines

While developing the CI recreational marine engine standards we analyzed two alternative approaches. The first approach was to apply the draft European Commission recreational marine emission standards to CI recreational marine engines used in the United States. Another approach we considered was to implement the CI recreational marine engine standards on the same schedule as for commercial marine engines. These two alternative approaches are discussed below.

11.1.1 Harmonization with Draft EC Standards

Several manufacturers commented that we should finalize the emission standards proposed by the European Commission (EC) for CI recreational marine engines for our national standards. These emission levels are presented in Table 11.1-1. This table also presents the U.S. standards finalized today and average baseline emissions based on data presented earlier in Chapter 4 on engines for which we had data on both HC+NOx and PM.[yy] Based on this data, we believe that the proposed European emissions standards for recreational marine diesel engines may not result in a decrease in emissions, and may even allow an increase in emissions from engines operated in the U.S. because current engines are already performing better than the proposed EC limits. Also, because the Clean Air Act directs us to set standards that "achieve the greatest degree of emission reduction achievable" given appropriate considerations, we do not believe it would be appropriate to finalize emission standards at the levels proposed by the European Commission.

[yy] If we include HC+NOx data from engine tests that did not include PM measurement, the HC+NOx average decreases to 8.6 g/kW-hr.

Table 11.1-1
EPA and Proposed European Standards Compared to Average Baseline Levels for CI Recreational Marine Emissions

Pollutant	EPA Standards g/kW-hr	Proposed EC Standards g/kW-hr	Baseline Emissions g/kW-hr
HC+NOx	7.2-7.5	9.8 NOx, 1.5 HC*	9.2
PM	0.2-0.4	1.4	0.2
CO	5.0	5.0	1.3

* HC increases slightly with increasing power rating.

We are not presenting an analysis of the cost per ton of emission reduction for this approach because we do not believe that it would result in emission reductions. However, the engine manufacturers would still need to incur the certification and compliance costs presented in Chapter 5. Therefore, setting a standard equal to the draft EC standards would likely result in costs with few or no benefits.

11.1.2 Earlier Implementation Dates Consistent with Commercial Marine

We believe that the emission-reduction strategies expected for land-based nonroad diesel engines and commercial marine diesel engines will also be applied to recreational marine diesel engines. Marine diesel engines are generally derivatives of land-based nonroad and highway diesel engines. Marine engine manufacturers and marinizers make modifications to the engine to make it ready for use in a vessel. These modifications can range from basic engine mounting and cooling changes to a restructuring of the power assembly and fuel management system. Because we anticipate that the same or similar technology will be used to meet the recreational and commercial marine standards, we considered including recreational marine engines in the commercial marine program with the same implementation dates.

Engine manufacturers commented that recreational marine engines need at least two years of lead time after the commercial marine standards to transfer technology from commercial marine engines to recreational marine engines and to stagger the need for manufacturers' research and development costs. We agree that this is necessary. In current production practices, the recreational marine engines are designed to operate at a higher power to weight ratio than commercial engines which requires development efforts specific to these engines. Although we believe that the same technology can be applied to recreational and commercial marine engines to reduce emissions, we recognize that individual development efforts will be required. In current practices, manufacturers stagger their development schedules to effectively use resources which include engineering hours and test cell time. If we were to require that recreational marine engines meet the new standards in the same year as commercial marine engines, manufacturers would likely need to double their research and development resources. We do not consider it practical for a manufacturer to do this in time for earlier standards, especially if the resources are only needed for two years. By allowing an additional two years of lead time, manufacturers are better able to stagger their development efforts.

The advantage of the earlier implementation dates would be to achieve emission reductions two years earlier. This would not likely affect the hardware costs discussed in Chapter 5, but would significantly increase the research and development costs if new people had to be hired and new facilities constructed. In fact, manufacturers would not likely have enough time to increase their research and development resources in time to meet earlier implementation dates. Therefore we are giving two years of additional lead time for recreational marine engines beyond the commercial marine implementation dates.

11.2 Large Industrial Spark-Ignition Engines

Of the several possibilities for Large SI engines, we are choosing one alternative over several others. For example, we are not analyzing the alternative of adopting only 2004 standards. Given the California certification data showing that some manufacturers are already achieving 2007 emission levels (with steady-state testing). This alternative would therefore clearly not meet the Clean Air Act direction to adopt the most stringent standards achievable.

Second, we are not analyzing a scenario of more stringent emission standards. The 2007 standards follow directly from available emission test data showing what level of emission control is achievable in that time frame. Any significant emission reductions beyond the 2007 standards would be appropriate to consider for a third tier of emission standards. Once manufacturers gain experience with the new emission-control technologies and the measurement procedures, additional information will be available to help us evaluate the relative costs and benefits of more stringent standards. Such information is not available today.

Third, we are not considering the approach of requiring forklifts to convert to battery power. We don't believe this would be an appropriate policy under Clean Air Act section 213, as described in the Summary and Analysis of Comments. An analysis comparing the life-cycle costs and benefits of the two alternative power sources for forklifts would provide useful information to consumers interested in evaluating their available choices. However, such an analysis is outside the scope of this rulemaking.

The alternative we have chosen to analyze captures a common input from those commenting on the proposal. Manufacturers generally questioned the need, value, or cost-effectiveness of adopting emission procedures requiring transient engine operation. To evaluate this more carefully, we analyzed the scenario of adopting the 2007 standards based only on steady-state emission measurement. To assess this alternative, we have calculated the costs and emission reductions associated with adding the transient controls to an engine already meeting the 2007 standards with steady-state testing.

Estimating the costs of controlling transient emissions is straightforward, with two simplifying assumptions. First, we need to assume that the technology and costs associated with the 2004 standards presented in Chapter 5 are sufficient to achieve the 2007 standards with steady-state testing. The existing California certification data support this. Second, even though the 2007 cost estimates include an allowance for meeting diagnostic requirements and field-testing standards, in this analysis we assign the full estimated cost of meeting the 2007 standards to upgrading for transient control. The resulting estimated first-year cost of $27 per engine therefore somewhat overestimates the actual cost . This includes engineering time to improve calibrations with the existing hardware, so there are no variable costs under this scenario.

To estimate the emission reductions associated with the transient test procedure, we rely primarily on the transient adjustment factors described in Chapter 6. Applying the transient adjustment factor leads to increased emissions of about 0.77 g/hp-hr HC+NOx and 3 g/hp-hr CO. Factoring in the lifetime operating parameters from the NONROAD model leads to a discounted lifetime emission reduction per engine of 0.22 tons for HC+NOx and 0.76 tons for CO. Comparing costs and emission reductions yields an estimated cost of about $200 per ton HC+NOx. Estimated nationwide emission reductions after fully phasing in the emission standards are 17,000 tons HC, 36,000 tons NOx, and 188,000 tons CO. These figures represent the incremental benefit of adding transient test procedures for the Tier 2 standards.

This analysis supports the decision to adopt emission standards requiring control of emissions during transient operation.

11.3 Recreational Vehicle Exhaust Emission Standards

11.3.1 Off-highway Motorcycles

We are presenting an analysis of two alternatives to the 2.0 g/km HC+NOx standard contained in the Final Rule, a less stringent and a more stringent alternative. The less stringent alternative we are presenting is a 4.0 g/km HC+NOx standard in the same time frame as the 2.0 g/km standard (50 and 100% phase-in for 2006 and 2007). We are finalizing this standard as an option to the 2.0 g/km standard with the provision that a manufacturer must certify all of their products, including machines that may otherwise meet the exemption for vehicles used solely for competition, to the 4.0 g/km standard. This alternative is numerically less stringent than the 2.0 g/km standard, but may actually result in more significant emission reductions than the final program since machines that may otherwise be exempt in the final program are included in the optional 4.0 g/km standard. Most competition off-highway motorcycles that could meet the competition exemption use high performance two-stroke engines that have HC levels significantly higher than the standard.

The second alternative we are presenting is the 2.0 g/km standard with an additional more stringent Phase 2 standard of 1.0 g/km phased in at 50 and 100% in 2009 and 2010. We proposed this alternative for ATVs, but not for off-highway motorcycles. It is clear from our analysis of technology, the current off-highway motorcycle market, and the comments received from manufacturers that four-stroke engines are technologically within reach for all off-highway motorcycle applications. While it is less clear, based on our analysis of technology and comments received from manufacturers and user groups it appears that direct fuel injection for two-stroke engines may also be within reach for some off-highway motorcycle applications. An analysis of the costs, emission reductions, costs per ton, and economic impacts of the alternatives are presented here. The methodology used for these analyses are the same as those described for the final program in the previous chapters.

11.3.1.1 Per Unit Costs

We have analyzed a less stringent standard of 4.0 g/km HC+NOx phased in at 50 and 100% in 2006 and 2007. The per unit average cost for this alternative is presented in Table 11.3.1-1 below. The average costs are based on a technology mix that includes the use of four-stroke engines and direct fuel injection for two-stroke engines. Because off-highway motorcycles have been using four-stroke engines for a many years and there is a significant number of these engines sold, the cost of using a four-stroke engine is less than the cost of using a direct fuel injection system with a two-stroke engine. Since we do not anticipate that any direct fuel injection two-stroke engines will be capable of meeting the final standard of 2.0 g/km HC+NOx, the resulting average cost for this alternative is somewhat higher than that of the final program, which we estimated at $158 per unit (see Chapter 5).

Table 11.3.1-1
Estimated Average Costs For Off-Highway Motorcycle Alternative 1 (4.0 g/km)

		Cost	Lifetime Fuel Savings (NPV)	Baseline	Control	Incremental Cost	Incremental Fuel Savings (NPV)
< 125 cc (31%)	4-stroke engine	$219	($140)	55%	85%	$66	$42
	Direct injection	$375	($140)	0%	15%	$56	$21
	compliance	$7	--	0%	100%	$7	--
	total	--	--	--	--	$129	$63
125 < 250 cc (27%)	4-stroke engine	$286	($140)	29%	85%	$160	$78
	Direct injection	$375	($140)	0%	15%	$56	$21
	compliance	$7	--	0%	100%	$7	--
	total	--	--	--	--	$223	$99
≥ 250 cc (42%)	4-stroke engine	$353	($140)	29%	85%	$198	$78
	Direct injection	$375	($140)	0%	15%	$56	$21
	compliance	$7	--	0%	100%	$7	--
	total					$71	$99
Near Term Composite Incremental Cost		--	--	--	--	$210	$88
Long Term Composite Incremental Cost		--	--	--	--	$127	$88

We have also analyzed an alternative that would include our final standard of 2.0 g/km plus a Phase 2 standard of 1.0 g/km that would be phased in at 50 and 100% in 2009 and 2010. This additional level of control would require R&D beyond that projected for the final 2.0 g/km standard and the incorporation of additional controls for four-stroke engines. We are projecting that at least half of off-highway motorcycle models would be equipped with catalysts in order to meet this level of stringency. The estimated average per unit costs for Phase 2 incremental to Phase 1 are provided in Table 11.3.1-2. We estimate that Phase 2 would cost about $70 incremental to Phase 1.

Table 11.3.1-2
Estimated Average Costs For Phase 2 Off-highway Motorcycles (Phase 2 = 1.0 g/km)
(Non-competition models only)

		Cost	Lifetime Fuel Savings (NPV)	Baseline	Control	Incremental Cost	Incremental Fuel Savings (NPV)
< 125 cc (37%)	4-stroke engine	$219	($140)	100%	100%	$0	$0
	pulse air	$39	$0	25%	75%	$19	$0
	R&D including recalibration	$15	$0	0%	100%	$15	$0
	Catalyst	$68	$0	0%	50%	$34	$0
	compliance	$1	--	0%	100%	$1	--
	total	--	--	--	--	$70	$0
125 < 250 cc (21%)	4-stroke engine	$286	($140)	100%	100%	$0	$0
	pulse air	$39	$0	0%	25%	$19	$0
	R&D including recalibration	$15	$0	0%	100%	$15	$0
	Catalyst	$68	$0	0%	50%	$34	$0
	compliance	$1	--	0%	100%	$1	--
	total	--	--	--	--	$70	$0
≥ 250 cc (42%)	4-stroke engine	$353	($140)	100%	100%	$0	$0
	pulse air	$39	$0	0%	25%	$19	$0
	R&D including recalibration	$15	$0	0%	100%	$15	$0
	Catalyst	$70	$0	0%	50%	$35	$0
	compliance	$1	--	0%	100%	$1	--
	total					$71	$0
Near Term Composite Incremental Cost		--	--	--	--	$70	$0
Long Term Composite Incremental Cost		--	--	--	--	$28	$0

11.3.1.2 Aggregate Cost Estimates

Based on the above per unit costs, we have estimated the aggregate costs for the two alternatives. The aggregate costs for Alternative 2 includes the costs for both phases of standards. The aggregate costs for the alternatives are provided in Table 11.3.1-3, along with the aggregate cost estimates for the final off-highway motorcycle program, which are estimated in Chapter 5. The fuel savings for both alternatives result from the switching of two-stroke to four-stroke engines. Alternative 1 also experiences fuel savings by the incorporation of competition machines into the program. Competition machines would either switch from two-stroke to four-stroke engines or use direct fuel injection with two-stroke engines. Direct fuel injection with two-stroke technology can result in similar fuel savings as converting from two-stroke to four-stroke engines.

Table 11.3.1-3
Summary of Annual Aggregate Costs and Fuel Savings (millions of dollars)

	2006	2010	2015	2020	2025
OHMC Final Program	$16.27	$24.24	$21.53	$22.63	$23.79
Alternative 1	$30.68	$46.56	$42.90	$45.09	$47.39
Alternative 2	$16.27	$34.25	$28.53	$29.99	$31.52
Fuel Savings (Alt 1)	$1.32	$14.13	$30.62	$39.05	$41.98
Fuel Savings (Alt 2)	$0.63	$7.23	$16.19	$21.03	$22.65

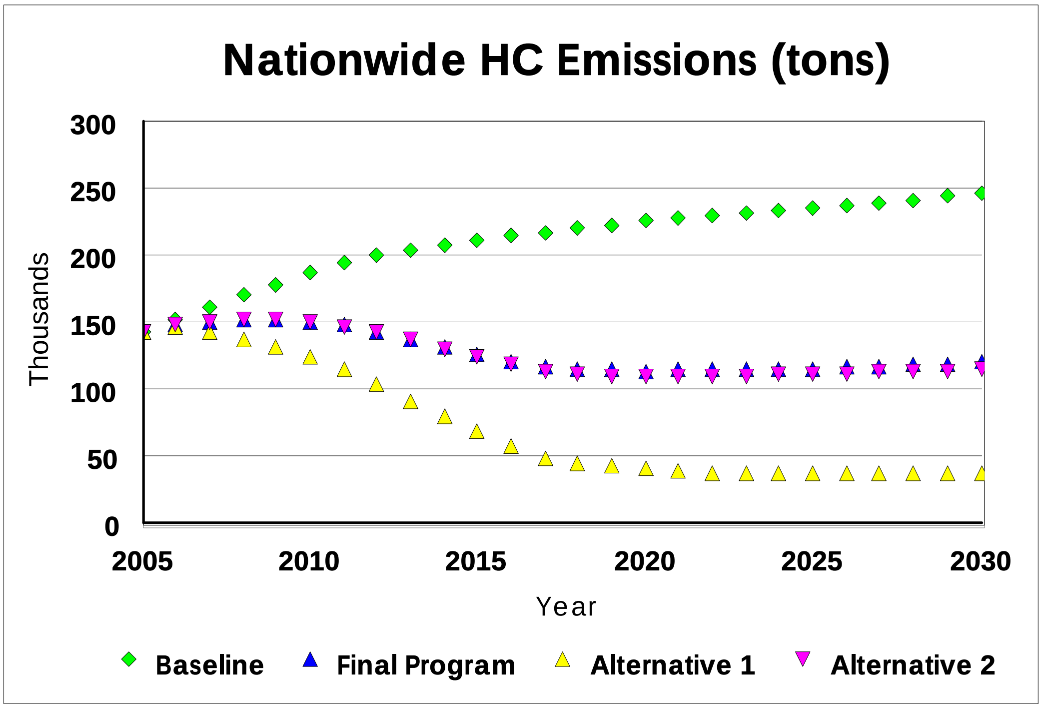
11.3.1.3 Emissions Reductions

In Chapter 6, we estimated the emissions reductions for the final program. We have estimated the emissions reductions from both alternatives using the same methodology. We would expect NOx and CO to be similar under the various alternatives. The results for HC are shown in Table 11.3.1-4 and in the Figure 11.3.1-1. The majority of the HC emissions reductions occur due to switching those remaining two-stroke off-highway motorcycles over to four-stroke technology. We expect this to occur in each of the alternatives we have analyzed. Alternative 1 has significantly greater reductions than alternative 2 or the final program, even though the numerical standard is less stringent. This is due to the fact that alternative 1 includes all off-highway motorcycles. Machines that may otherwise qualify for the competition exemption make up 29-percent of off-highway motorcycle sales, and they tend to use high-performance two-stroke engines that emit very high levels of HC emissions. Controlling HC emissions from these machines to the alternative 1 standard of 4.0 g/km would result in significant reductions.

Table 11.3.1-4
Summary of HC Reductions (thousands of tons)

	2006	2010	2015	2020	2025
OHMC Final Program	3.1	36.3	84.1	111.1	120.0
Alternative 1	5.7	63.4	142.6	184.9	199.2
Alternative 2	3.1	36.8	86.6	115.4	124.8

Figure 11.3.1-1
Off-Highway Motorcycle HC Emissions Inventory



11.3.1.4 Cost Per Ton

Chapter 7 provides the cost per ton estimate for the final program. Using the same methodology, we have estimated the cost per ton of HC+NOx reduced for the two alternatives. The results are provided in Table 11.3.1-5. The results of Alternative 2 Phase 2 are based on the incremental change from 2.0 g/km to 1.0 g/km.

Table 11.3.1-5
Estimated Off-Highway Motorcycle Average
Cost Per Ton of HC + NOx Reduced (7 percent discount rate)

	Lifetime Reductions per Vehicle (NPV tons)	Discounted Per Vehicle Costs Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Costs Per Ton with Fuel Savings ($/ton)
Final Program	0.38	$410	$280
Alternative 1	0.50	$420	$210
Alternative 2 Phase 1	0.38	$410	$280
Alternative 2 Phase 2*	0.02	$3,590	$3,590

* Phase 2 standards incremental to Phase 1

11.3.1.5 Economic Impacts Analysis

The human health and environmental benefits and economic costs of the regulatory alternatives for off-highway motorcycles are presented. The methodologies used to estimate the economic costs of these alternatives are discussed extensively in Chapter 9. We are presenting two alternatives to the 2.0 g/km HC+NOx standard contained in the Final Rule, a less stringent and a more stringent alternative.

Table 11.3.1-6
Economic Costs of Alternative
Off-Highway Motorcycle Standards—Values in 2030 (millions of 2001$)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
OHM Final Program	$25.9	$25.0	$25.2	$0.2
Alternative 1	$33.1	$31.7	$46.4	$14.7
Alternative 2	$49.8	$46.6	$25.2	($21.5)

1 Economic costs or net economic costs shown in parenthesis. Additional important considerations, such as potential safety impacts discussed below, are not reflected in these cost estimates.

Table 11.3.1-7a
Economic Costs of Alternative Off-Highway Motorcycle Standards—Net Present Value 2002 through 2030 (millions of 2001$, using 3 percent discount rate)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
OHM Final Program	$372.6	$358.9	$242.4	($116.5)
Alternative 1	$461.4	$441.1	$467.8	26.7
Alternative 2	$712.0	$663.1	$242.4	($420.7)

1 Economic costs or net economic costs shown in parenthesis.

Table 11.3.1-7b
Economic Costs of Alternative Off-Highway Motorcycle Standards—Net Present Value 2002 through 2030 (millions of 2001$, using 7 percent discount rate)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
OHM Final Program	$214.3	$206.3	$120.6	($85.6)
Alternative 1	$261.6	$249.9	$232.5	($17.4)
Alternative 2	$408.6	$379.9	$120.6	($259.3)

1 Economic costs or net economic costs shown in parenthesis.

11.3.1.6 Discussion

Although alternative 1 is numerically less stringent than the final standard of 2.0 g/km HC+NOx, it would result in significant additional emissions reductions from the final program. These reductions are gained by the inclusion of machines that could otherwise qualify as vehicles used solely for competition into the program. The CAA requires that competition vehicles be exempt from emission regulations. Moreover, the 4.0 g/km standard would not otherwise meet the CAA requirements that standards achieve the greatest degree of emissions reduction achievable through use of available technology, taking cost, noise, energy, and safety into account. Therefore, this alternative cannot be considered as a replacement to the final program. However, the potential for significant emission reductions resulting from the control of competition machines is very desirable. That is why we are finalizing alternative 1 as an option to the 2.0 g/km HC+NOx standard in the final program. This option would result in the use of four-stroke engines and two-stroke engines equipped with direct fuel injection.

Alternative 2 would require manufacturers to achieve reductions beyond those required by the California off-highway motorcycle program. We believe that manufacturers would be required to use high levels of pulse air and would also need to use catalysts on some models. As discussed in Chapter 4, there are still concerns over the safety, durability and feasibility of the widespread use of catalysts on off-highway motorcycles. We are concerned that catalysts could pose safety threats from burns to individual riders as well as the potential for setting fires in the riding environment, which is frequently forests and grassy fields. There are also concerns over the ability of a catalyst to be able to physically survive in the very harsh environment that off-highway motorcycles frequently operate in. In general, we have concerns about the feasibility of many advanced emission control technologies with off-highway motorcycle applications. Off-highway motorcycles are exposed to dirt, dust, mud, water, rocks, etc. All of which make the use of relatively fragile technology such as electronic fuel injection and secondary air injection questionable. This alternative is based on the standards we proposed for ATVs but are not finalizing. As discussed in detail in the preamble for the Final Rule, we are not finalizing this level of control for ATVs due to concerns about the ability of manufacturers to meet the standards within the time frame proposed. These same concerns apply to off-highway motorcycles. We believe additional testing and analysis is needed before we can affirm the feasibility of Phase 2 standards.

11.3.2 All-terrain Vehicles

We are presenting an analysis of two alternatives to the 1.5 g/km HC+NOx standard contained in the Final Rule, a less stringent and a more stringent alternative. The less stringent alternative we are presenting is a 2.0 g/km HC+NOx standard in the same time frame as the 1.5 g/km standard (50 and 100 % phase-in for 2006 and 2007). The second alternative we are presenting is the 2.0 g/km alternative with an additional more stringent Phase 2 standard of 1.0 g/km phased in at 50/100% in 2009/2010. We proposed but did not finalize two phases of standards for ATVs and the second alternative analyzed below is based on the proposed standards. It is clear from our analysis of technology, the current ATV market, and the comments received from manufacturers that 4-stroke engines are technologically within reach for all ATV applications. Therefore, the focus of the alternatives analysis is on what level of control to require from 4-stroke ATVs. An analysis of the costs, emissions reductions, costs per ton, and economic impacts of the alternatives are presented here. The methodology used for these analyses are the same as those described for the final program in the previous chapters. Also, the costs for the various technologies is presented in Chapter 5. Finally, a discussion of why these alternatives were not chosen for the Final Rule is provided in Section 11.3.2.6.

11.3.2.1 Per unit Costs

We have analyzed a less stringent standard of 2.0 g/km HC+NOx phased in at 50 and 100% in 2006 and 2007. The per unit average cost for this alternative is presented in Table 11.3.2-1 below. The average costs are based on a technology mix similar to that of the final 1.5 g/km standard, but with less reliance on reducing emissions from the 4-stroke engines through the use of recalibration and secondary air. This results in an average cost that is somewhat lower than that of the final program, which we estimated would cost $87 per unit (see Chapter 5).

Alternative 2 would require manufacturers to achieve reductions beyond those required by the California off-highway motorcycle program. We believe that manufacturers would be required to use high levels of pulse air and would also need to use catalysts on some models. As discussed in Chapter 4, there are still concerns over the safety, durability and feasibility of the widespread use of catalysts on off-highway motorcycles. We are concerned that catalysts could pose safety threats from burns to individual riders as well as the potential for setting fires in the riding environment, which is frequently forests and grassy fields. There are also concerns over the ability of a catalyst to be able to physically survive in the very harsh environment that off-highway motorcycles frequently operate in. In general, we have concerns about the feasibility of many advanced emission control technologies with off-highway motorcycle applications. Off-highway motorcycles are exposed to dirt, dust, mud, water, rocks, etc. All of which make the use of relatively fragile technology such as electronic fuel injection and secondary air injection questionable. This alternative is based on the standards we proposed for ATVs but are not finalizing. As discussed in detail in the preamble for the Final Rule, we are not finalizing this level of control for ATVs due to concerns about the ability of manufacturers to meet the standards within the time frame proposed. These same concerns apply to off-highway motorcycles. We believe additional testing and analysis is needed before we can affirm the feasibility of Phase 2 standards.

Table 11.3.2-1
Estimated Average Costs For a ATV Alternative 1 (2.0 g/km)

		Cost	Lifetime Fuel Savings (NPV)	% of use Baseline	% of use Control	Incrementa l Cost	Incremental Fuel Savings (NPV)
< 200 cc (15%)	4-stroke engine	$219	($124)	8%	100%	$202	($114)
	pulse air	$33	$0	0%	25%	$8	$0
	R&D for exhaust including recalibration	$16	$0	0%	50%	$8	$0
	permeation control	$3	($5)	0%	100%	$3	($5)
	compliance	$13	--	0%	100%	$13	--
	total	--	--	--	--	$234	($119)
> 200 cc (85%)	4-stroke engine	$349	($124)	93%	100%	$24	($9)
	pulse air	$27	$0	0%	25%	$7	$0
	R&D for exhaust including recalibration	$5	$0	0%	50%	$2	$0
	permeation control	$3	($5)	0%	100%	$3	($5)
	compliance	$12	--	0%	100%	$12	--
	total	--	--	--	--	$49	($13)
Near Term Composite Incremental Cost		--	--	--	--	$76	($29)
Long Term Composite Incremental Cost		--	--	--	--	$36	($29)

Table 11.3.2-2
Estimated Average Costs For ATV Alternative 2 (Phase 2 =1.0 g/km)

		Cost	Lifetime Fuel Savings (NPV)	% of use, Phase 1 = 2.0 g/km	% of use, Phase 2 = 1.0 g/km	Incrementa l Cost	Incremental Fuel Savings (NPV)
< 200 cc (15%)	4-stroke engine	$219	($124)	100%	100%	$0	$0
	pulse air	$33	$0	0%	50%	$16	$0
	R&D for exhaust including recalibration for Phase 2	$16	$0	0%	100%	$16	$0
	Catalyst	$68	$0	50%	100%	$34	$0
	compliance	$2	--	0%	100%	$2	--
	total	--	--	--	--	$68	$0
> 200 cc (85%)	4-stroke engine	$349	($124)	100%	100%	$0	$0
	pulse air	$27	$0	0%	50%	$14	$0
	R&D for exhaust including recalibration for Phase 2	$5	$0	0%	100%	$5	$0
	Catalyst	$70	$0	50%	100%	$35	$0
	compliance	$2	--	0%	100%	$2	--
	total	--	--	--	--	$54	$0
Near Term Composite Incremental Cost		--	--	--	--	$56	$0
Long Term Composite Incremental Cost		--	--	--	--	$30	$0

11.3.2.2 Aggregate Cost Estimates

Based on the above per unit costs, we have estimated the aggregate costs for the two alternatives. The aggregate costs for Alternative 2 includes the costs for both phases of standards. The aggregate costs for the alternatives are provided in Table 11.3.2-3, along with the aggregate cost estimates for the final ATV program, which are estimated in Chapter 5. The fuel savings result from switching from 2-stroke to 4-stroke engines and are the same for each alternative.

Table 11.3.2-3
Summary of Annual Aggregate Costs and Fuel Savings (millions of dollars)

	2006	2010	2015	2020	2025
ATV Final Program	$42.46	$65.30	$52.44	$47.56	$47.56
Alternative 1	$37.43	$57.11	$48.18	$43.29	$43.29
Alternative 2	$37.43	$102.58	$77.28	$72.39	$72.39
Fuel Savings	$0.93	$15.14	$36.22	$48.84	$51.00

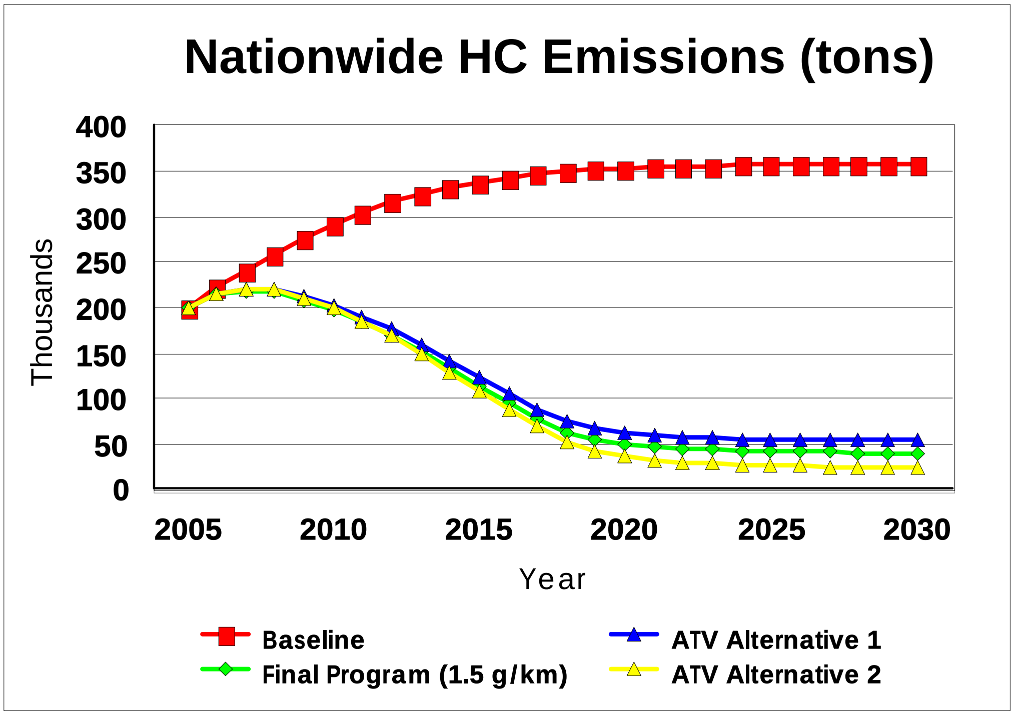
11.3.2.3 Emissions Reductions

In Chapter 6, we estimated the emissions reductions for the final program. We have estimated the emissions reductions for both alternatives using the same methodology. We would expect NOx and CO to be similar under the various alternatives. The results for HC are shown in Table 11.3.2-4 and in the following figure. The majority of the HC emissions reductions occur due to switching those remaining 2-stroke ATVs over to 4-stroke technology. The base emission factor is about 34 g/km for that 20 percent of the ATV fleet which is two-stroke and 1.8 g/km for the remaining 80 percent which are four stroke. Thus, even though eliminating the four strokes is significant the reductions from the four strokes is large as well. We expect this to occur in each of the alternatives we have analyzed.

Table 11.3.2-4
Summary of HC Reductions (thousands of tons)

	2006	2010	2015	2020	2025
ATV Final Program	6.2	92.4	225.0	304.1	315.5
Alternative 1	5.9	88.0	214.9	291.0	302.0
Alternative 2	5.9	91.1	230.4	317.0	331.0

Figure 11.3.2-1: ATV HC Emissions Inventory



11.3.2.4 Cost Per Ton

Chapter 7 provides the cost per ton estimates for the final program. Using the same methodology, we have estimated the cost per ton of HC+NOx reduced for the two alternatives. The results are provided in table 11.3.2-5. The results for Alternative 2 Phase 2 are based on the incremental change from 2.0 g/km to 1.0 g/km.

Table 11.3.2-5
Estimated ATV Average
Cost Per Ton of HC + NOx Reduced (7 percent discount rate)

	Lifetime Reductions per Vehicle (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
Final Program	0.21	$400	$290
Alternative 1	0.20	$370	$250
Alternative 2 Phase 1	0.20	$370	$250
Alternative 2 Phase 2*	0.02	$2,700	$2,700

* Phase 2 standards incremental to Phase 1

11.3.2.5 Economic Impacts Analysis

The economic costs of the regulatory alternatives for ATVs are presented. The methodologies used to estimate economic costs of these alternatives are discussed extensively in Chapter 9. We are presenting two alternatives to the 1.5 g/km HC+NOx standard contained in the Final Rule, a less stringent and a more stringent alternative.

Table 11.3.2-6
Economic Costs of Alternative ATV Standards—Values in 2030 (millions of 2001$)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
ATV Final Program	$496.3	$491.9	$253.0	($238.9)
Alternative 1	$445.2	$441.7	$253.0	($188.6)
Alternative 2	$662.0	$654.1	$253.0	($401.0)

1 Economic costs or net economic costs shown in parenthesis.

Table 11.3.2-7a
Economic Costs of Alternative ATV Standards
Net Present Value 2002 through 2030
(millions of 2001$, using 3 percent discount rate)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
ATV Final Program	$836.3	$829.2	$510.5	($318.7)
Alternative 1	$752.9	$747.0	$510.5	($236.5)
Alternative 2	$1,154.1	$1,140.5	$510.5	($630.0)

1 Economic costs or net economic costs shown in parenthesis.

Table 11.3.2-7b
Economic Costs of Alternative ATV Standards
Net Present Value 2002 through 2030
(millions of 2001$, using 7 percent discount rate)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
ATV Final Program	$836.3	$829.2	$510.5	($318.7)
Alternative 1	$752.9	$747.0	$510.5	($236.5)
Alternative 2	$1,154.1	$1,140.5	$510.5	($630.0)

1 Economic costs or net economic costs shown in parenthesis.

11.3.2.6 Discussion

Alternative 1 would require only modest additional emissions reductions from 4-strokes, in general, and many models would meet the standard in their base configuration. In addition, this alternative is less stringent than the current California standard for ATVs. Most, if not all 4-stroke ATV models are certified to the California requirements. We received support for harmonizing standards with California and this level of control is feasible for 4-stroke equipped ATVs. Therefore, we do not believe that a standard less stringent than that contained in the California program would meet the basic criteria of the Clean Air Act which requires us to set a standard based on the greatest degree of emission reduction achievable. Our consideration of costs and economic impacts did not change our view that a 1.5 g/km standard was appropriate for ATVs.

Alternative 2 would require manufacturers to achieve reductions beyond those required in by the California program. We believe that manufacturers would be required to use a high level of pulse air and would also need to use catalyst on some ATV models. For our cost analysis above, we projected that catalysts would be used on half of all ATV models. This alternative is based on the standards we proposed for ATVs but are not finalizing. As discussed in detail in the preamble for the Final Rule, we are not finalizing this level of control due to concerns about the ability of manufacturers to meet the standards within time frame proposed. We believe additional testing and analysis is needed before we can affirm the feasibility of the Phase 2 standards.

11.3.3 Snowmobiles

While developing the final snowmobile emissions standards we analyzed four alternative sets of emissions standards, including options both less stringent and more stringent than the final standards. These alternatives are as follows:

Alternative 1 - keeping the Phase 1 standards indefinitely (i.e., not adopting Phase 2 or Phase 3 standards)

Alternative 2 - adopting the snowmobile manufacturers' recommended phase 2 standards in 2010 (which provide a 50% reduction in HC but keep the CO standard at the phase 1 level), with no Phase 3 standards

Alternative 3 - adopting Phase 2 standards in 2010 based on a large percentage of four-stroke engines; (70% HC/30% CO) reduction

Alternative 4 - adopting more stringent Phase 2 in 2010 which would require optimized advanced technology on every snowmobile; (85% HC/50% CO) reduction.

All of these alternatives were modeled assuming 100 percent compliance with the Phase 1 standards in 2006, whereas the final program includes a phase in with 50 percent compliance in 2006 and 100 percent compliance in 2007.

In addition to these alternative standards scenarios, we looked at what would happen if four-stroke engine technology cost 25 percent more than we originally projected in order to assess the sensitivity to four-stroke technology costs. This sensitivity analysis was done on Alternative 4. This scenario will be referred to as Alternative 5 for the remainder of this snowmobile section.

11.3.3.1 Per unit Costs

The per unit costs for the various alternatives are shown in Tables 11.3.3-1 through 11.3.3-5. Also included in these tables are the technology mixes we used for each of the alternatives. The per unit costs for alternative 1 (Phase 1 standards only) shown in Table 11.3.3-1 are identical to the per unit costs for Phase 1 of the final program. The near term composite incremental costs of all of the other alternatives can be compared to the near term incremental cost of $89 for Phase 3 of the final program, as shown in Table 5.2.3-22 in Chapter 5.

Table 11.3.3-1
Estimated Average Costs For Snowmobiles (Alternative 1 - Phase 1 only)

		Cost	Lifetime Fuel Savings	Baseline	Phase 1	Incremental Cost	Incremental Fuel Savings
< 500 cc (30%)	engine modifications	$18	$0	0%	60%	$11	$0
	modified carburetor	$18	$0	0%	60%	$11	$0
	direct injection*	$328	($512)	7%	10%	$10	($15)
	electronic fuel injection	$175	$0	12%	15%	$5	$0
	4-stroke engine	$455	($512)	7%	10%	$14	($15)
	permeation control	$7	($10)	0%	100%	$7	($10)
	compliance	$12	--	0%	100%	$12	$0
	total	--	--	--	--	$69	($40)
≥ 500 cc (70%)	engine modifications	$25	$0	0%	60%	$15	$0
	modified carburetor	$24	$0	0%	60%	$14	$0
	direct injection*	$295	($1,139)	7%	10%	$9	($34)
	electronic fuel injection	$119	$0	12%	15%	$4	$0
	4-stroke engine	$770	($1,139)	7%	10%	$23	($34)
	permeation control	$7	($10)	0%	100%	$7	($10)
	compliance	$12	$0	0%	100%	$12	$0
	total	--	--	--	--	$84	($78)
Near Term Composite Incremental Cost		--	--	--	--	$80	($67)
Long Term Composite Incremental Cost		--	--	--	--	$47	($67)

Table 11.3.3-2
Estimated Average Costs For Snowmobiles (Alternative 2 - Phase 2 HC standards with Phase 1 CO standards)

		Cost	Lifetime Fuel Savings	Phase 1	Phase 2	Incremental Cost	Incremental Fuel Savings
< 500 cc (30%)	pulse air/recalibration	$41	$0	0%	30%	$12	$0
	direct injection*	$328	($512)	10%	35%	$82	($128)
	electronic fuel injection	$175	$0	15%	20%	$9	$0
	4-stroke engine	$455	($512)	10%	15%	$23	($26)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$128	($154)
≥ 500 cc (70%)	pulse air/recalibration	$41	$0	0%	30%	$12	$0
	direct injection*	$295	($1,139)	10%	35%	$74	($285)
	electronic fuel injection	$119	$0	15%	20%	$6	$0
	4-stroke engine	$770	($1,139)	10%	15%	$39	($57)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$132	($342)
Near Term Composite Incremental Cost		--	--	--	--	$131	($286)
Long Term Composite Incremental Cost		--	--	--	--	$77	($286)

* Direct injection costs are an average of the air-assisted and pump assisted system costs.

Table 11.3.3-3
Estimated Average Costs For Snowmobiles (Alternative 3 - Four-stroke based Phase 2 Standards)

		Cost	Lifetime Fuel Savings	Phase 1	Phase 2	Incrementa l Cost	Incremental Fuel Savings
< 500 cc (30%)	pulse air/recalibration	$41	$0	0%	25%	$10	$0
	direct injection*	$328	($512)	10%	10%	$0	$0
	electronic fuel injection	$175	$0	15%	65%	$87	$0
	4-stroke engine	$455	($512)	10%	60%	$228	($256)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$327	($256)
≥ 500 cc (70%)	pulse air/recalibration	$41	$0	0%	25%	$10	$0
	direct injection*	$295	($1,139)	10%	10%	$0	$0
	electronic fuel injection	$119	$0	15%	65%	$60	$0
	4-stroke engine	$770	($1,139)	10%	60%	$385	($570)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$457	($570)
Near Term Composite Incremental Cost		--	--	--	--	$418	($476)
Long Term Composite Incremental Cost		--	--	--	--	$260	($476)

* Direct injection costs are an average of the air-assisted and pump assisted system costs.

Table 11.3.3-4
Estimated Average Costs For Snowmobiles
(Alternative 4 - Phase 2 Standards based on broad application of advanced technology)

		Cost	Lifetime Fuel Savings	Phase 1	Phase 2	Incrementa l Cost	Incremental Fuel Savings
< 500 cc (30%)	pulse air/recalibration	$41	$0	0%	0%	$12	$0
	direct injection*	$328	($512)	10%	10%	$0	$0
	electronic fuel injection	$175	$0	15%	90%	$131	$0
	4-stroke engine	$455	($512)	10%	90%	$364	($410)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$497	($410)
$\geq$ 500 cc (70%)	pulse air/recalibration	$41	$0	0%	0%	$	$0
	direct injection*	$295	($1,139)	10%	10%	$0	$0
	electronic fuel injection	$119	$0	15%	90%	$90	$0
	4-stroke engine	$770	($1,139)	10%	90%	$616	($911)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$718	($911)
Near Term Composite Incremental Cost		--	--	--	--	$652	($760)
Long Term Composite Incremental Cost		--	--	--	--	$410	($760)

* Direct injection costs are an average of the air-assisted and pump assisted system costs.

Table 11.3.3-5
Estimated Average Costs For Snowmobiles (Alternative 4 with 25% higher 4-stroke costs)

		Cost	Lifetime Fuel Savings	Phase 1	Phase 2	Incrementa l Cost	Incremental Fuel Savings
< 500 cc (30%)	pulse air/recalibration	$41	$0	0%	0%	$12	$0
	direct injection*	$328	($512)	10%	10%	$0	$0
	electronic fuel injection	$218	$0	15%	90%	$164	$0
	4-stroke engine	$569	($512)	10%	90%	$455	($410)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$621	($410)
≥ 500 cc (70%)	pulse air/recalibration	$41	$0	0%	0%	$	$0
	direct injection*	$295	($1,139)	10%	10%	$0	$0
	electronic fuel injection	$149	$0	15%	90%	$112	$0
	4-stroke engine	$963	($1,139)	10%	90%	$770	($911)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$894	($911)
Near Term Composite Incremental Cost		--	--	--	--	$812	($760)
Long Term Composite Incremental Cost		--	--	--	--	$512	($760)

* Direct injection costs are an average of the air-assisted and pump assisted system costs.

11.3.3.2 Aggregate Cost Estimates

Based on the above per unit costs, we have estimated the aggregate costs for the alternatives. The aggregate costs for the alternatives are presented in Table 11.3.3-6, along with the aggregate cost estimates for the final snowmobile program, which are estimated in Chapter 5. The fuel savings result in varying degrees of switching from current two-stroke technology to direct injection two-stroke and four-stroke technology.

Table 11.3.3-6
Summary of Annual Snowmobile Aggregate Costs and Fuel Savings (millions of dollars)

	2006	2010	2015	2020	2025
Final program	$6.58	$37.55	$41.91	$41.56	$41.56
Alternative 1	$13.17	$12.07	$11.08	$11.73	$11.73
Alternative 2	$13.17	$38.99	$28.65	$30.32	$30.32
Alternative 3	$13.17	$98.99	$70.03	$74.13	$74.13
Alternative 4	$13.17	$148.68	$104.08	$110.17	$110.17
Alternative 5	$13.17	$182.23	$127.25	$134.69	$134.69
Fuel savings (Final program)	$0.78	$11.81	$58.23	$103.00	$123.66
Fuel Savings (Alt 1)	$0.78	$4.31	$9.13	$12.33	$13.51
Fuel Savings (Alt 2)	$0.78	$8.81	$38.59	$66.73	$79.60
Fuel Savings (Alt 3)	$0.78	$11.81	$58.23	$103.00	$123.66
Fuel Savings (Alt 4)	$0.78	$16.31	$87.68	$157.40	$189.75
Fuel Savings (Alt 5)	$0.78	$16.31	$87.68	$157.40	$189.75

11.3.3.3 Emissions Reductions

In Chapter 6, we estimated the emissions reductions for the final program. We have estimated the emissions reductions for the alternatives using the same methodology. The results for HC are shown in Table 11.3.3-7 and in Figure 11.3.3-1, while the results for CO are shown in Table 11.3.3-8 and in Figure 11.3.3-2.

As can be seen in Tables 11.3.3-7 and 11.3.3-8, there are cases where the emissions reductions for a given pollutant are different for different alternatives even though the numerical limits for that pollutant are the same for those alternatives. For example, the final program and

Alternative 2 would both require 50 percent reductions in HC, but the HC reductions shown in Table 11.3.3-7 are different for these two options. The reason for this difference in HC reductions is that under these two options the CO limits are different. Under the final program the CO limit would require a 50 percent reduction in CO, while in Alternative 2 the CO reductions would only be 30 percent. This difference in CO limits results in the need for a different technology mix being needed under the two alternatives. The more aggressive application of technology needed under the final program to meet the CO limit has the effect of producing somewhat higher HC reductions. Similarly, the different HC limits for Alternatives 1 through 3 result in different technology mixes for the these alternatives. These different technology mixes result in different CO reductions for each alternative even though the CO limits are the same for all three alternatives. This can be seen in Tale 11.3.3-8.

Table 11.3.3-7
Summary of Snowmobile HC Reductions (thousands of tons)

	2006	2010	2015	2020	2025
Final Program	4.0	42.9	123.3	196.1	230.4
Alternative 1	7.9	44.9	98.4	135.1	148.5
Alternative 2	7.9	47.3	114.2	165.2	185.6
Alternative 3	7.9	52.1	146.8	227.6	262.4
Alternatives 4 and 5	7.9	55.8	172.4	276.4	322.4

Table 11.3.3-8
Summary of Snowmobile CO Reductions (thousands of tons)

	2006	2010	2015	2020	2025
Final Program	9.9	105.3	285.0	442.2	513.4
Alternative 1	19.9	112.7	246.6	338.7	372.3
Alternative 2	19.9	116.2	270.1	383.6	427.7
Alternative 3	19.9	120.1	296.6	436.8	493.1
Alternatives 4 and 5	19.9	123.1	317.4	476.8	544.0

Figure 11.3.3-1 Snowmobile HC Emissions Inventory

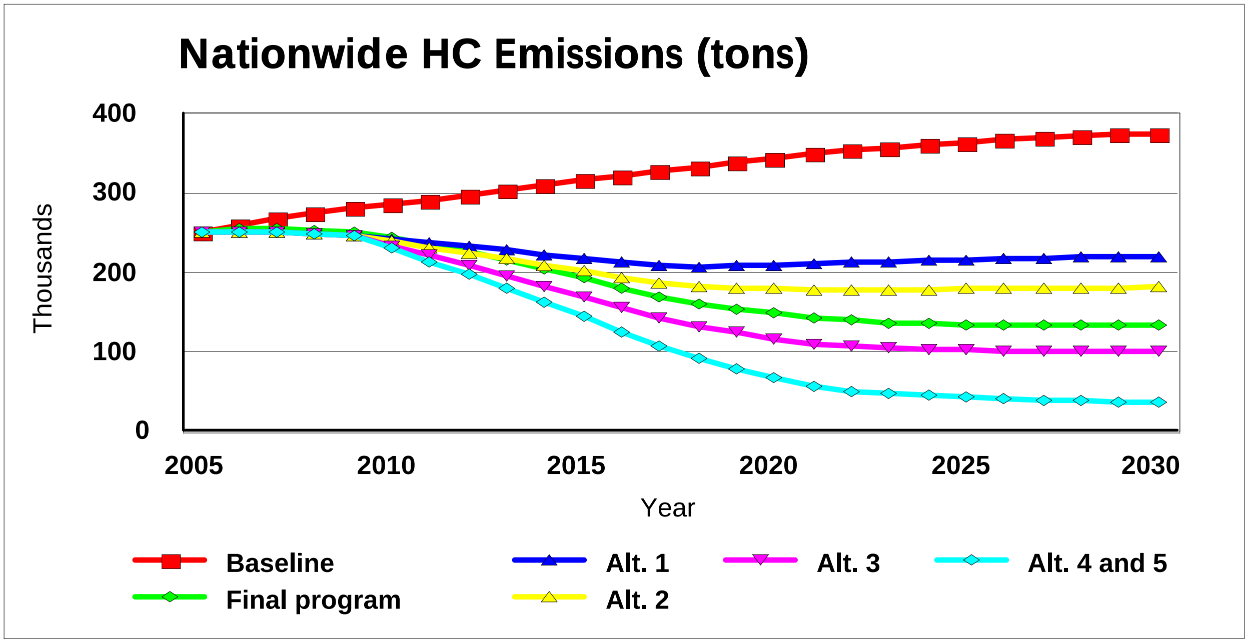
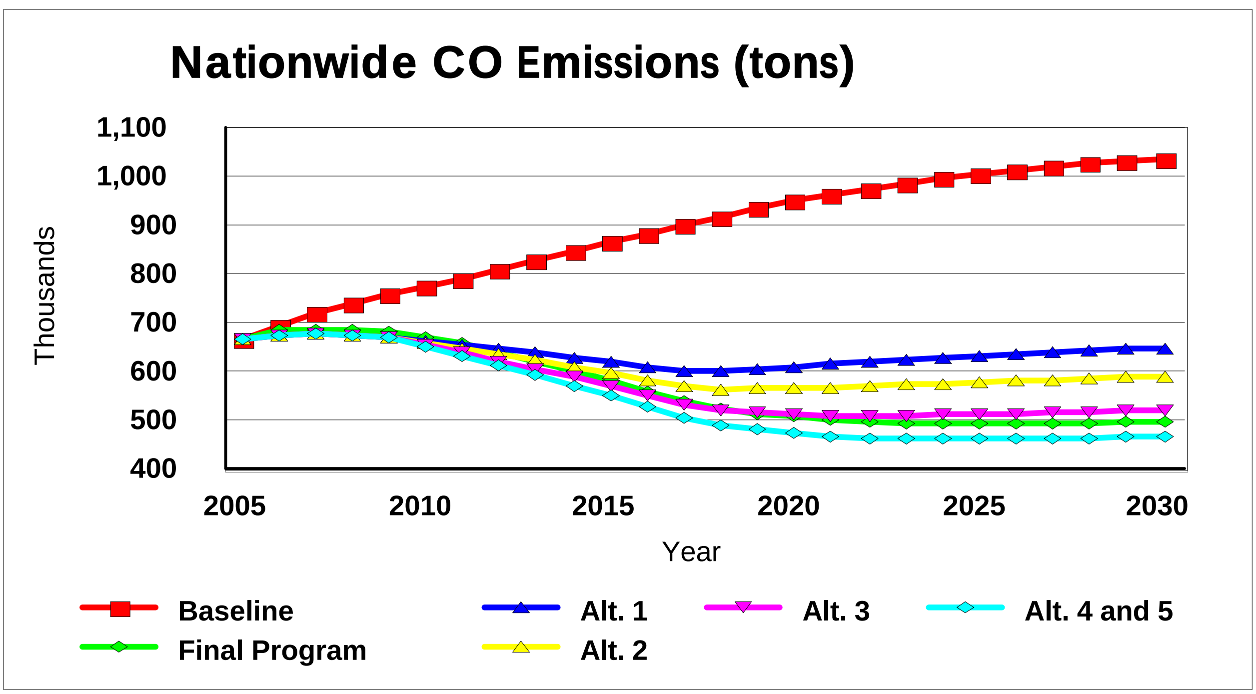


Figure 11.3.3-2 Snowmobile CO Emissions Inventory



11.3.3.4 Cost Per Ton

Chapter 7 provides the cost per ton estimates for the final program. Using the same methodology, we have estimated the cost per ton of HC and CO reduced for the alternatives, as shown in Table 11.3.3-9. The results for alternative 1 (Phase 1 standards only) are shown first. All other scenarios, including the final program, are base on the incremental change from the Phase 1 standards to whatever Phase 2 standards are considered in the particular scenario.

Table 11.3.3-9
Estimated Snowmobile Average Cost per Ton of HC and CO Reduced
(7 percent discount rate)

	Lifetime Reductions per Vehicle (NPV tons)		Discounted per Vehicle Cost Per Ton without Fuel Savings ($/ton)		Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)	
	HC	CO	HC	CO	HC	CO
Alternative 1	0.40	1.02	$90	$40	$20	$10
Final Program[c]	n/a	0.25	n/a	$360	n/a	($410)
Alternative 2[a]	0.10	n/a	$1,370	n/a	($1,610)	n/a
Alternative 3[a]	0.28	n/a	$1,480	n/a	($210)	n/a
Alternative 4[a]	0.49	0.50	$670	650	($110)	($110)
Alternative 5[a,b]	0.49	0.50	$840	$810	($50)	($50)

a. Shown based on incremental change from Phase 1 standards.
b. Alternative 4 with 25% higher 4-stroke cost.
c. Shown based on incremental change from Phase 2 standards

11.3.3.5 Economic Impacts Discussion

The economic costs of the regulatory alternatives for snowmobiles are presented. Net social costs (or gains) of the alternatives in the year 2030 are shown on Table 11.3.3-10, while the net present value of these costs through 2030 are reflected on Tables 11.3.3-11a and 11.3.3-11b. The methodologies used to estimate the economic costs of these alternatives are discussed extensively in Chapter 9. Each of the alternatives, is modeled based on a 30 percent reduction in HC and CO, respectively during Phase 1 of the regulation.

Table 11.3.3-10
Economic Costs of Alternative Snowmobile Standards—
Values in 2030[1,3] (millions of 2001$)

Scenario	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[2]
Alternative 1	$11.7	$11.6	$18.2	$6.6
Alternative 2	$30.3	$29.8	$88.0	$58.2
Final Program	$43.1	$41.9	$135.0	$93.1
Alternative 3	$74.1	$70.5	$134.5	$64.0
Alternative 4	$111.2	$102.1	$204.3	$102.2
Alternative 5[4]	$134.7	$122.7	$204.3	$81.6

1. Assumes the final program Phase 1 standards as the first phase in each alternative
2. Economic costs or net economic costs shown in parenthesis.
3. Dollar values are rounded to the nearest 10 million.
4. Same standards as Alternative 4, but assumes a 25% increase in the cost of a 4-stroke engine.

Table 11.3.3-11a
Economic Costs of Alternative Snowmobile Standards—
Net Present Value 2002 through 2030[1]
(millions of 2001$, using 3 percent discount rate)

Scenario	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[2]
Alternative 1	$183.7	$182.1	$174.7	($7.4)
Alternative 2	$426.9	$418.9	$697.7	$278.8
Final Program	$569.6	$553.1	$999.6	$446.5
Alternative 3	$987.6	$885.0	$1,046.3	$161.3
Alternative 4	$1,450.1	$1,335.0	$1,569.3	$234.3
Alternative 5[3]	$1,763.8	$1,591.8	$1,569.3	($22.5)

1. Assumes the final program Phase 1 standards as the first phase in each alternative
2. Economic costs or net economic costs shown in parenthesis.
3. Same standards as Alternative 4, but assumes a 25% increase in the cost of a 4-stroke engine.

Table 11.3.3-11b
Economic Costs of Alternative Snowmobile Standards—
Net Present Value 2002 through 2030[1]
(millions of 2001$, using 7 percent discount rate)

Scenario	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[2]
Alternative 1	$106.6	$105.7	$86.8	($18.9)
Alternative 2	$235.7	$231.1	$327.2	$96.1
Final Program	$305.7	$296.9	$459.7	$162.8
Alternative 3	$531.5	$470.0	$487.4	$17.4
Alternative 4	$775.7	$713.1	$727.8	$14.7
Alternative 5[3]	$941.1	$847.6	$727.8	($119.8)

1. Assumes the final program Phase 1 standards as the first phase in each alternative
2. Economic costs or net economic costs shown in parenthesis.
3. Same standards as Alternative 4, but assumes a 25% increase in the cost of a 4-stroke engine.

11.3.3.6 Discussion

Alternative 1 (Phase 1 standards only) would require relatively minimal additional use of advanced technologies beyond what we project as a baseline. These advanced technologies (direct injection two-stroke, and four-stroke technologies) have been shown to be both feasible and capable of emissions reductions well below those required of the Phase 1 standards. Thus, we do not believe that this alternative would meet the basic criteria of the Clean Air Act which requires us to set standards based on the greatest degree of emissions reductions achievable.

Alternative 2 (Phase 2 HC standards with Phase 1 CO standards) would require roughly half of new snowmobiles to have advanced technology beginning with the 2010 model year, with the emphasis on direct injection two-stroke technology. The remaining snowmobiles would have a combination of engine modifications, recalibration and electronic fuel injection. We believe that a higher level of advanced technology than 50 percent penetration is certainly feasible beyond 2010 and therefore do not believe that in the absence of more stringent Phase 3 standards this alternative would meet the basic criteria of the Clean Air Act which requires us to set standards based on the greatest degree of emissions reductions achievable.

Alternative 3 (more stringent Phase 2 HC standards than final program in conjunction with Phase 1 CO standards) would require more advanced technology. We modeled 60 percent of the snowmobiles produced would be powered by four-stroke engines in 2010 and an additional ten percent would utilize direct injection two-stroke technology. The remainder would require some other technologies such as recalibrations and electronic fuel injection. We believe that these alternative standards strike a reasonable balance for allowing four stroke engines to be a primary Phase 2 technology, and have adopted these standards as an alternative to our primary Phase 2 standards on an engine family by engine family basis. Further discussion of our reasons for offering these standards as a Phase 2 option can be found in the preamble to the final rule.

Alternative 4 would require advanced technologies on all snowmobiles, beginning in 2010. We modeled 90 percent requiring four-stroke engines and the remaining ten percent requiring direct injection two-stroke technology. As discussed in detail in the preamble, given the number of snowmobile models and engine model offerings for each snowmobile model, and the fact that snowmobiles have not previously been regulated or used these advanced technologies in large numbers, we do not believe that it is feasible to apply and optimize advanced technology to every snowmobile by the 2010 model year. Thus we are not confident that this option is would be feasible in the time frame provided. We will, however, monitor the development and application of advanced technology and will in the future consider the adoption of snowmobile standards that would require advanced technology on every snowmobile.

Alternative 5 is simply a sensitivity analysis to look at how the cost of four-stroke engines might impact the consideration of Phase 2 standards which are based largely on four-stroke technology. This alternative has the same standards as Alternative 4, but with 25 percent higher costs for four-stroke engines.

11.4 Recreational Vehicle Permeation Emission Standards

While developing the fuel tank and hose permeation standards, we analyzed alternative approaches both more and less stringent than the final standards. These alternative approaches are discussed below.

11.4.1 Fuel Tanks

The final permeation standard for fuel tanks is 1.5 $g/m^2/day$ when tested at 23°C on a test fuel with 90 percent gasoline and 10 percent ethanol. This standard represents approximately an 85 percent reduction from baseline HDPE fuel tanks. We considered an alternative standard equivalent to about a 60 percent reduction from baseline. This could be met by fuel tanks molded out of nylon. We also considered requiring metal fuel tanks which would essentially eliminate permeation emissions from fuel tanks.

11.4.1.1 60 Percent Reduction (Nylon Fuel Tanks)

One manufacturer commented that we should relax the fuel tank standard to a 55-60 percent reduction so that other technologies could be used. Specifically, they point to injection-molded nylon. Therefore, for this analysis, we consider the costs and emissions reductions associated with molding the fuel tank out of nylon.

As discussed in Chapter 5, nylon costs about $2.00 per pound while HDPE costs about $0.50 per pound. Depending on the shape of the fuel tank and the wall thickness, recreational vehicle fuel tanks weigh about 1-1.3 pounds per gallon. Including a 29% markup for overhead and profit, the increased cost for using nylon fuel tanks would be about $21 for snowmobiles (11 gallons), $10 for ATVs (4 gallons), and $8 for off-highway motorcycles (3 gallons). This is actually 5-10 times higher than our projected costs for using sulfonation to meet the final standard which represents about an 85 percent reduction.

Based on the data presented in Chapter 4, the use of nylon could achieve more than a 95 percent reduction in permeation compared to HDPE when gasoline is used. However, if a 10 percent ethanol blend is considered, then the reduction is only 40-60 percent depending on the nylon composition. On a 15 percent methanol blend, the permeation rate through nylon can actually be several times higher than through HDPE.

About one third of the gasoline sold in the U.S. today is blended with ethanol or some other oxygenate. In addition, the trend in the U.S. is towards using more renewable fuel and ethanol may be the leading choice. Therefore, it is important that the permeation control strategy used for recreational vehicles be effective on ethanol fuel blends. For this analysis, we consider a

10 percent ethanol blend when calculating emissions reductions.

Table 11.4-1 presents the projected national emission reductions for this approach. These figures can be compared to the anticipated reductions presented in Chapter 6 for the final standards (Table 6.2.6-3). Table 11.4-2 presents the cost per ton of permeation emissions reduced per fuel tank, using a 7 percent discount rate, with and without fuel savings. These figures can be compared to the cost per ton presented in Chapter 7 (Table 7.1.5-1).

Table 11.4-1
Projected Fuel Tank Permeation Emissions from Recreational Vehicles for the Alternative Approach of a 60 Percent Reduction [short tons]

Vehicle	Scenario	2000	2005	2010	2020	2030
Snow-mobiles	baseline control reduction	3,389 3,389 0	4,181 4,181 0	5,032 4,106 92	6,456 2,737 3,719	7,061 2,824 4,236
ATVs	baseline control reduction	3,985 3,985 0	6,751 6,751 0	9,275 8,072 1,202	11,109 5,455 5,654	11,231 4,539 6,692
OHMCs	baseline control reduction	882 882 0	1,303 1,303 0	1,710 1,492 218	2,061 1,239 821	2,248 1,315 933
Total	baseline control reduction	8,255 8,255 0	12,234 12,234 0	16,016 13,671 2,345	19,626 9,431 10,194	20,539 8,678 11,862

Table 11.4-2
Estimated Cost Per Ton of HC Reduced (7 percent discount rate) for the Alternative Approach of a 60 Percent Reduction from Fuel Tanks

	Total Cost Per Vehicle	Lifetime Fuel Savings Per Vehicle (NPV)	Lifetime Reductions Per Vehicle (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
Snowmobiles	$21	$3	0.0084	$2,541	$2,178
ATVs	$10	$2	0.0047	$2,065	$1,702
OHMC	$8	$1	0.0027	$2,819	$2,456

Constructing fuel tanks out of nylon would be significantly more expensive than constructing them out of HDPE and applying a barrier treatment such as sulfonation to control permeation. Therefore, we believe that most manufacturers would choose the lower cost option of applying a barrier treatment even if we were to set a standard based on a 60 percent reduction. In addition, we believe that they would target the maximum effectiveness of the barrier treatment. Designing for a 60 percent reduction would not have meaningful cost savings over designing for a 95 percent reduction. As a result, while this option could result in less emission control than the standard, we do not believe that it would lower costs for manufacturers.

11.4.1.2 Metal Fuel Tanks

One commenter pointed out that essentially a 100 percent reduction in fuel tank permeation emissions could be achieved by replacing plastic fuel tanks with metal fuel tanks. However, they stated that a performance standard approaching this amount of emission reduction would be appropriate because it would allow industry flexibility on how to meet the standard. For this scenario we consider the use of metal fuel tanks in recreational vehicles.

Today, most if not all recreational vehicles use plastic fuel tanks. According to manufacturers plastic fuel tanks are desirable because they weigh less than metal fuel tanks, are more durable, can be formed into more complex shapes, are non-corrosive, and cost less. In recreational vehicle applications, weight is an issue because the vehicles must be light enough to be manipulated by the rider. However, more importantly, durability is an issue because of the rough use of these vehicles and because many of the fuel tanks are exposed. For example, if a dirt bike were to fall over, a metal tank could be dented on a rock which would damage the integrity of the fuel tank. A plastic tank, however, would likely be undamaged. In addition metal fuel tanks have seams due to the manufacturing process which are weak point and could result in leaking. Fuel tanks on recreational vehicles, are designed to maximize the fuel stored in a limited space. Current plastic fuel tank designs are molded with contours that match the vehicle chassis. Manufacturers have stated that these complex shapes cannot be stamped into metal parts and that using metal tanks could cause them to need to redesign the fuel tank geometry and could require modifications to the chassis in order to maintain the same fuel capacity.

For the purposes of this analysis we use a cost increase of 30 percent for metal tanks versus plastic fuel tanks. This is based on pricing seen for marine applications which use metal fuel tanks in some cases. Because metal fuel tanks are not used in recreational vehicle applications, direct costs cannot be used. This cost does not include research and design costs that would be required for developing metal tanks or costs of modifying production practices. Dealer prices for plastic fuel tanks, of the size used in recreational vehicles, range from 3 to 9 dollars per gallon of capacity.[1] Using an average cost of 6 dollars per gallon and a typical dealer markup, we get a cost of about 2 dollars per gallon for plastic fuel tanks. This cost estimate for plastic fuel tanks was confirmed in conversations with recreational vehicle manufacturers. Based on this analysis and a markup of 29%, we estimate a cost increase of about $9 for snowmobiles, $3 for ATVs, and $2 for non-competition off-highway motorcycles.

Table 11.4-3 presents the projected national emission reductions for this approach. These figures can be compared to the anticipated reductions presented in Chapter 6 for the final standards (Table 6.2.6-3). Table 11.4-4 presents the cost per ton of permeation emissions reduced per fuel tank, using a 7 percent discount rate, with and without fuel savings. These figures can be compared to the cost per ton presented in Chapter 7 (Table 7.1.5-1).

Table 11.4-3
Projected Fuel Tank Permeation Emissions from Recreational Vehicles for the Alternative Approach of a 100 Percent Reduction [short tons]

Vehicle	Scenario	2000	2005	2010	2020	2030
Snow-mobiles	baseline	3,389	4,181	5,032	6,456	7,061
	control	3,389	4,181	3,489	258	0
	reduction	0	0	1,542	6,198	7,061
ATVs	baseline	3,985	6,751	9,275	11,109	11,231
	control	3,985	6,751	7,271	1,685	78
	reduction	0	0	2,004	9,424	11,153
OHMCs	baseline	882	1,303	1,710	2,061	2,248
	control	882	1,303	1,347	692	692
	reduction	0	0	363	1,369	1,556
Total	baseline	8,255	12,234	16,016	19,626	20,539
	control	8,255	12,234	12,107	2,635	770
	reduction	0	0	3,909	16,991	19,769

Table 11.4-4
Estimated Cost Per Ton of HC Reduced (7 percent discount rate) for the Alternative Approach of a 100 Percent Reduction

	Total Cost Per Vehicle	Lifetime Fuel Savings Per Vehicle (NPV)	Lifetime Reductions Per Vehicle (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
Snowmobiles	$9	$5	0.0140	$668	$305
ATVs	$3	$3	0.0078	$435	$72
OHMC	$2	$2	0.0046	$509	$146

Although this approach appears to be cost effective, we did not chose to set standards that would require manufacturers to use metal fuel tanks. We believe that there may be safety concerns with metal fuel tanks on recreational vehicles because of the rough use and likelihood of damage to the fuel tanks. Because some applications may be able to use metal fuel tanks, we will accept a metal tank for design-based certification to our standard. In addition, we believe that the final tank permeation standard can achieve nearly the same level of reduction as metal tanks while providing manufacturers very important flexibility in their design and manufacturing.

11.4.2 Hoses

The hose standard is 15 g/m^2/day when tested at 23°C on a test fuel with 90 percent gasoline and 10 percent ethanol (E10). For hoses we considered basing the standard on testing with an alcohol-free test fuel. We also considered a standard that would require the use of fuel tubing, such as used in automotive applications, which is fairly rigid in comparison to fuel hoses because tubing is generally constructed out of fluorothermoplastics while hoses are primarily constructed out of rubber.

11.4.2.1 Alcohol-Free Test Fuel

Manufacturers commented that we should specify ASTM Fuel C (50% toluene, 50% iso-octane) for the hose permeation testing, stating that this is the fuel used for measuring permeation under the SAE J30 recommended practice for R9 hose. Under SAE J30, R9 hose must meet a permeation rate of 15 g/m^2/day when tested at 23°C. Manufacturers noted that fuels with ethanol-gasolines blends would have a higher permeation rate than if they were tested on gasoline. Therefore, R9 hose would not necessarily meet the hose permeation standards. As noted in Chapter 4, barrier materials typically used in R9 hose today may have permeation rates 3 to 5 times higher on a 10 percent ethanol blend than on straight gasoline. In this section, we analyze the alternative of basing our hose permeation standard on testing using an alcohol-free test fuel.

For the purposes of our benefits analysis, as described in Chapter 6, we estimated that a hose designed to meet 15 g/m^2/day on E10 fuel would permeate at half of that rate when tested on gasoline. This estimate considers the entire hose construction and not just the effect of alcohol on the barrier materials. To model this alternative, we doubled the estimated permeation rates for hoses meeting the permeation standards. Based on costs of hose available today, R9 hose would cost about $0.75/ft which represents a $0.50/ft increase from R7 hose used in most applications today. For the same reasons as discussed in Chapter 5, we are conservatively adding a cost of hose clamps ($0.20 each). As with the analysis in Chapter 5, we include a 29 percent markup in costs for profit and overhead.

Table 11.4.1-5 presents the projected national emission reductions for this approach. These figures can be compared to the anticipated reductions presented in Chapter 6 for the final standards (Table 6.2.6-4). Table 11.4-6 presents the cost per ton of permeation emissions reduced per fuel tank, using a 7 percent discount rate, with and without fuel savings. These figures can be compared to the cost per ton presented in Chapter 7 (Table 7.1.5-1).

Table 11.4-5
Projected Fuel Hose Permeation Emissions from Recreational Vehicles for the Alternative Approach of Using an Alcohol-Free Test Fuel [short tons]

Vehicle	Scenario	2000	2005	2010	2020	2030
Snow-mobiles	baseline	4,471	5,516	6,638	8,517	9,315
	control	4,471	5,516	4,659	564	254
	reduction	0	0	1,979	8,074	9,061
ATVs	baseline	4,243	7,189	9,876	11,829	11,959
	control	4,243	7,189	7,800	2,068	407
	reduction	0	0	2,076	9,761	11,552
OHMCs	baseline	1,878	2,774	3,642	4,389	4,787
	control	1,878	2,774	2,890	1,553	1,565
	reduction	0	0	751	2,836	3,222
Total	baseline	10,592	15,478	20,156	24,735	26,061
	control	10,592	15,478	15,349	4,184	2,225
	reduction	0	0	4,806	20,550	23,835

Table 11.4-6
Estimated Cost Per Ton of HC Reduced (7 percent discount rate) for the Alternative Approach of Using an Alcohol-Free Test Fuel [short tons]

	Total Cost Per Vehicle	Lifetime Fuel Savings Per Vehicle (NPV)	Lifetime Reductions Per Vehicle (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
Snowmobiles	$4	$7	0.0179	$212	($151)
ATVs	$1	$3	0.0081	$144	($219)
OHMC	$2	$3	0.0095	$157	($206)

We also received comment that we should use the most permeable fuel blend on the market for testing the permeation rates through hoses. As discussed above, we believe that the use of ethanol-blended gasoline is too significant today to ignore and could increase in the future. For this reason, we believe that it is appropriate to base the standards on testing using E10 fuel. We do not believe it is necessary to relax the standards to allow R9 hose to be able to pass on E10 fuel. Several materials are available today that could be used as a low permeation barrier in rubber hoses that are resistant to permeation on alcohol fuel blends. In fact, SAE J30 specifies R11 and R12 hose which are low permeability hoses tested on 15 percent methanol blend. Chapter 4 presents data on low permeation hoses developed for automotive applications that easily meet the final hose permeation standards that we believe could be used on recreational applications. Finally, the incremental cost is small ($0.10/ft) between hose that would meet 15 g/m^2/day on straight gasoline versus gasoline with a 10 percent ethanol blend.

11.4.2.2 Automotive Plastic Fuel Tubing

In developing emission standards for nonroad vehicles, the Clean Air Act requires us to first consider standards for comparable on-highway applications. In automotive applications, manufacturers generally use very low permeation plastic fuel tubing to meet our evaporative emission requirements. Recommended practice specified by SAE J2260 defines a Category 1 fuel line which must meet a permeation requirement of 25 g/m^2/day at 60°C on a test fuel with 85 percent gasoline and 15 percent methanol (M15). This is roughly equivalent to meeting a limit of 2 g/m^2/day at 23°C. In addition, based on the data in Chapter 4, permeation rates for most materials used in hoses tend to be at least twice as high for M15 than E10 fuel. This plastic tubing is generally made of fluoropolymers such as ETFE or PVDF.

Manufacturers commented that fuel hose standards based on automotive fuel lines such as specified in SAE J2260[2] as Category 1 would be inappropriate for recreational vehicles. Although this technology can achieve more than an order of magnitude lower permeation than barrier hoses, it is relatively inflexible and may need to be molded in specific shapes for each recreational vehicle design. Manufacturers have commented that they would need flexible hose to fit their many designs, resist vibration, and to simplify the hose connections and fittings.

Plastic fuel tubing would likely cost less than multilayer barrier fuel hoses, but we estimate that it would cost about $0.50 per foot more than the rubber hoses currently used on recreational vehicles. This additional cost includes a markup to form the tubing to the tight bends that would be required for recreational applications. Although the fluoroplastics are more expensive than the materials used in hoses on a per pound basis, plastic automotive tubing is constructed with thin walls (approximately 1 mm on average). An additional cost associated with automotive fuel tubing would be for more sophisticated connectors for the plastic tubing. On recreational vehicles using rubber fuel hose, the hose is generally just pushed on to connectors formed into the fuel tank and carburetor. In some cases, these are push on fittings without the use of a clamp. In automotive applications, quick connects are generally used which cost about $0.50 each.[3] For ATVs and OHMCs, we include the costs of two quick connects for each vehicle. Snowmobiles can require 4 to 8 quick connects depending on the fuel pump configuration, number of carburetors, and if a fuel return line is included. We include the cost of six quick connects in this analysis.

Table 11.4-7 presents the projected national emission reductions for this approach. These figures can be compared to the anticipated reductions presented in Chapter 6 for the final standards (Table 6.2.6-4). Table 11.4-8 presents the cost per ton of permeation emissions reduced per fuel tank, using a 7 percent discount rate and a 29 percent markup for overhead and profit, with and without fuel savings. These figures can be compared to the cost per ton presented in Chapter 7 (Table 7.1.5-1).

Table 11.4-7
Projected Fuel Hose Permeation Emissions from Recreational Vehicles for the Alternative Approach of Basing the Standard on Automotive Fuel Tubing [short tons]

Vehicle	Scenario	2000	2005	2010	2020	2030
Snow-mobiles	baseline control reduction	4,471 4,471 0	5,516 5,516 0	6,638 4,605 2,033	8,517 348 8,169	9,315 8 9,306
ATVs	baseline control reduction	4,243 4,243 0	7,189 7,189 0	9,876 7,744 2,132	11,829 1,804 10,026	11,959 93 11,865
OHMCs	baseline control reduction	1,878 1,878 0	2,774 2,774 0	3,642 2,870 772	4,389 1,476 2,913	4,787 1,478 3,310
Total	baseline control reduction	10,592 10,592 0	15,478 15,478 0	20,156 15,219 4,936	24,735 3,627 21,107	26,061 1,579 24,481

Table 11.4-8
Estimated Cost Per Ton of HC Reduced (7 percent discount rate) for the Alternative Approach of Basing the Standard on Automotive Fuel Tubing

	Total Cost Per Vehicle	Lifetime Fuel Savings Per Vehicle (NPV)	Lifetime Reductions Per Vehicle (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
Snowmobiles	$6	$7	0.0184	$333	($30)
ATVs	$2	$3	0.0083	$233	($130)
OHMC	$2	$4	0.0097	$232	($131)

Although this approach appears to be cost effective, we did not choose to set standards that would require manufacturers to automotive type fuel tubing. We are concerned that the tubing is too rigid for the tight installation spaces and radii in recreational vehicle applications. Hoses on these vehicles today often have tight bends and are subject to high amounts of shock and vibration The above analysis does not include costs of adding additional length that may be required for molding in spirals or other bends for vibration resistance. Because some applications may be able to automotive fuel tubing, we will accept fuel lines conforming to SAE J2260 Category 1 for design-based certification to our standard. In addition, we believe that the final hose permeation standard can achieve nearly the same level of reduction as metal tanks while providing manufacturers flexibility in their design.

11.5 Incremental Cost Per Ton Analysis

The above discussion analyzes several options for the different engine categories. For completeness, we have also examined the cost per ton associated with the incremental steps in standards changes. The table below provides a summary of the incremental cost per ton for the differences in the alternatives analyzed above. Details of the alternative are provided above for each program.

Table 11.5-1: Incremental Cost Per Ton Estimates

Change in Standards	Average Cost		Lifetime Reductions per Vehicle (NPV tons) [a.]		Discounted per Vehicle Cost Per Ton without Fuel Savings ($/ton) [a.]		Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton) [a.]	
Off-highway Motorcycles (change in g/km HC+NOX standard)	w/o fuel savings	w/fuel saving	HC+NOx		HC+NOx		HC+NOx	
Baseline –> 4.0 g/km [b.]	$210	$122	0.50		$420		$210	
Baseline –> 2.0 g/km	$158	$105	0.38		$410		$280	
2.0 g/km –> 1.0 g/km	$70	$70	0.02		$3,590		$3,590	
ATVs (change in g/km HC+NOX standard)	w/o fuel savings	w/fuel saving	HC+NOx		HC+NOx		HC+NOx	
Baseline –> 2.0 g/km	$73	$50	0.20		$370		$250	
2.0 –> 1.5 g/km	$11	$11	0.01		$1,010		$1,010	
1.5 –> 1.0 g/km	$48	$48	0.01		$4,740		$4,740	
Snowmobiles (HC/CO percent reduction)	w/o fuel savings	w/fuel saving	HC	CO	HC	CO	HC	CO
Baseline –> 30/30	$80	$13	0.40	1.02	$90	$40	$20	$10
30/30 –> 50/30	$131	($155)	0.10	0.16	$1,370	n/a	($1,610)	n/a
50/30 –> 50/50	$89	($102)	n/a	0.25	n/a	$330	n/a	($430)
50/30 –> 70/30	$287	$97	0.19	n/a	$1,540	n/a	$520	n/a
70/30 –> 85/50	$234	($50)	0.14	0.15	$820	$780	$180	($170)
Large SI	w/o fuel savings	w/fuel saving	HC+NOx		HC+NOx		HC+NOx	
Baseline –> Phase 1	$611	($3,370)	3.07		$240		($1,150)	
Phase 1 –> Phase 2	$55	$55	0.80		$80		$80	

a. Calculated using a discount rate of 7 percent.
b. The 4.0 g/km alternative requires manufacturers to certify competition off-highway motorcycles whereas the other alternative does not.

Chapter 11 References

1.White, JJ and Carroll, JN. (1998) Emissions from snowmobile engines using bio-based fuels and lubricants. Final Report. Prepared for State of Montana Department of Environmental Quality. Southwest Research Institute report #7383.

2.U.S. EPA Guidelines for the Health Risk Assessment of Chemical Mixtures. EPA Report No. 630/R-98/002. September 24, 1986. Federal Register 51(185) : 34014 - 34025. http://cfpub.epa.gov/ncea/

3.White, JJ and Carroll, JN. (1998) Emissions from snowmobile engines using bio-based fuels and lubricants. Final Report. Prepared for State of Montana Department of Environmental Quality. Southwest Research Institute report #7383.

Buckingham, JP; White, JJ; and Carroll, JN. (1996) Development of snowmobile test cycle – final report. Southwest Research Institute report #7574.

4.Benignus, V, W Boyes, and P. Bushnell, US Environmental Protection Agency. National Health and Environmental Effects Research Laboratory. Memorandum to the Docket. Acute Behavioral Effects of Exposure to Toluene and Carbon Monoxide from Snowmobile Exhaust. September 2002.

1. www.marinepart.com/fuetmold, A copy of this has been placed in the Docket A-2000-01, Document IV-A-87.

2. SAE Recommended Practice J2260, “Nonmetallic Fuel System Tubing with One or More Layers,”1996, Docket A-2000-01, Document IV-A-18.

3. Denbow, R., Browning, L., Coleman, D., “Report Submitted for WA 2-9, Evaluation of the Costs and Capabilities of Vehicle Evaporative Emission Control Technologies,” ICF, ARCADIS Geraghty & Miller, March 22, 1999, Docket A-2000-01, Document No. IV-B-05.

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Air quality at a snowmobile staging area and snow chemistry on and off trail in a Rocky Mountain subalpine forest, Snowy Range, Wyoming

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Abstract A study was begun in the winter of 2000–2001 and continued through the winter of 2001–2002 to examine air quality at the Green Rock snowmobile staging area at 2,985 m elevation in the Snowy Range of Wyoming. The study was designed to evaluate the effects of winter recreation snowmobile activity on air quality at this high elevation site by measuring levels of nitrogen oxides (NO_x, NO), carbon monoxide (CO), ozone (O_3) and particulate matter (PM_{10} mass). Snowmobile numbers were higher weekends than weekdays, but numbers were difficult to quantify with an infrared sensor. Nitrogen oxides and carbon monoxide were significantly higher weekends than weekdays. Ozone and particulate matter were not significantly different during the weekend compared to weekdays. Air quality data during the summer was also compared to the winter data. Carbon monoxide levels at the site were significantly higher during the winter than during the summer. Nitrogen oxides and particulates were significantly higher during the summer compared to winter. Nevertheless, air pollutants were well dispersed and diluted by strong winds common at the site, and it appears that snowmobile emissions did not have a significant impact on air quality at this high elevation ecosystem. Pollutant concentrations were generally low both winter and summer. In a separate study, water chemistry and snow density were measured from snow samples collected on and adjacent to a snowmobile trail. Snow on the trail was significantly denser and significantly more acidic with significantly higher concentrations of sodium, ammonium, calcium, magnesium, fluoride, and sulfate than in snow off the trail. Snowmobile activity had no effect on nitrate levels in snow.

Keywords Anions · Carbon monoxide · Cations · Dispersion · High elevation · Nitrogen oxides · Ozone · Particulate matter · Winter recreation

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Introduction

Air quality in high elevation ecosystems in the western US is generally considered to be relatively good with low concentrations of air pollutants. However, high-elevation environments in the western United States are sensitive to the effects of atmospheric deposition derived from anthropogenic sources (Finley 1992). Nitrogen deposition is of particular importance in these ecosystems. Emissions of nitrogen oxides are increasing in the western US (Placet 1990), as well as nitrogen (N) deposition in terrestrial ecosystems (Fenn et al. 2003; Williams et al. 1996). Research has shown that atmospheric deposition can also cause major changes in aquatic ecosystems (Irving 1992; Schindler 1988).

The effect of emissions from snowmobile activity on air quality and deposition in high elevation ecosystems has been studied primarily at Yellowstone National Park (YNP) in NW Wyoming. Most snowmobiles currently are equipped with two-stroke engines that are more polluting than four-stroke engines (Bishop et al. 2001; USDI 2000). They emit hydrocarbons (HC), nitrogen oxides (NO_x), particulate matter (PM), carbon monoxide (CO), and non-combusted fuel vapors (USDI 2000). Combustion engine emissions contain carcinogens, including benzene, butadiene, and polycyclic aromatic hydrocarbons (USDI 2000). Combustion engines also emit large amounts of carbon dioxide. Extensive visitor use of snowmobiles has raised concerns about air quality (especially HC, VOC and CO) and park employee health at YNP. Bishop et al. (1999), (2001) documented 'in-use' snowmobile pollutant emissions (pollutant evaluation of snowmobiles in use for recreational travel) but did not directly address associated air quality issues. Kado et al. (2001) addressed the potential health hazards to park service employees by measuring ambient air quality at YNP's West Yellowstone entrance station and at a remote site near Old Faithful geyser. They found levels of CO, PM and VOC to be elevated but not in violation of recommended exposure limits for outdoor employees. However, the National Park Service (National Park Service 1995; USDI 2000) found concentrations of CO at the West Yellowstone entrance to exceed National Ambient Air Quality Standards (NAAQS) during periods of heavy snowmobile traffic (>450 snowmobiles per hour).

Other potentially deleterious effects of recreational snowmobile use have been documented, including wildlife disturbance (e.g., Creel et al. 2002) and health hazards to park employees (Kado et al. 2001) and snowmobile riders (Eriksson et al. 2003; Snook-Fussel 1997).

Atmospheric dry deposition (CASTNET[1]) and wet deposition (NADP[2]) monitored at the Glacier Lakes Ecosystem Experiments Site (GLEES), a high elevation alpine and subalpine research area in the Snowy Range of SE Wyoming (Musselman 1994), indicate that higher amounts of N deposition occur at this high elevation (3,200 m) site than at nearby lower elevations (Korfmacher and Musselman 2004), even though the site is remote from any major source of N emissions. Higher deposition is likely due to the higher precipitation loading, about 120 cm/year at the GLEES, primarily in the form of snow. Wind blown snow and dust also contributes to higher deposition at the GLEES.

Although much of the atmospheric deposition in remote areas such as the GLEES is thought to result from long-range transport, local sources of deposition cannot be discounted. Many public lands, including the Medicine Bow National Forest in southeastern Wyoming, are experiencing increased winter recreation snowmobile use. Use is often higher on weekends and holidays. It is possible that increased snowmobile use will increase the potential for impact in the Snowy Range of Wyoming.

Contribution of snowmobiles to chemical deposition to snow in this area is unknown, and information about deposition impacts of snowmobiles is limited. Research has shown that ammonium and sulfate concentrations in snow were higher under snow machine trails than off the trails, but nitrate concentrations did not change within 100 m of the trail (Ingersoll 1999; Ingersoll et al. 1997). Nitrates are of particular concern, since wet and dry deposited nitrates accumulate in the winter snowpack and can be an important source of N for plant growth (Bowman 1992); and can cause changes in ecosystem processes, species productivity, and composition to alpine meadows (Bowman and Steltzer 1998; Bowman et al. 1993). Interlandi and Kilham (1998) suggest that high elevation aquatic ecosystems are sensitive to N deposition from automobile and snowmobile emissions.

Snowmobile trails have been shown to increase snow density resulting in longer lasting, delayed, spring melt and lower temperature under the snow (Hogan 1972; Keddy et al. 1979; Wanek 1971); factors that may be important in plant species distribution (Atkin and Collier 1992; Kudo 1991; Walker et al. 1993). Damage to ecosystems from increased density of snowpack after snowmobile activity may be caused by acceleration of heat loss and colder temperatures

[1] CASTNET – Clean Air Status and Trends Network: http://www.epa.gov/castnet/.

[2] NADP – National Atmospheric Deposition Program: http://nadp.sws.uiuc.edu/.

under the snowpack (Keddy et al. 1979; Neumann and Merriam 1972; Pesant et al. 1985; Wanek 1971).

A study was conducted to monitor air quality at a snowmobile staging area and trailhead for a major groomed snowmobile trail in the Snowy Range in southeastern Wyoming. The site has different terrain and meteorological characteristics than the Yellowstone snowmobile area. Temporal investigation of the NO_x, CO, O_3 and PM dynamics of this study area provides information on present conditions and insight towards possible snowmobile contribution to changes in air quality at the site. A separate study not related to the air quality study at the snowmobile staging area examined snow density and snow water chemistry on and off a snowmobile trail about 2 km from the trailhead.

Materials and methods

The air quality monitoring study was conducted at the Green Rock Picnic Area snowmobile trailhead and staging area (Fig. 1), Medicine Bow National Forest, about 12 km west of Centennial, Wyoming at 2,985 m elevation in the Snowy Range of Wyoming. The road parallels a stream and is widened at the Green Rock site for parking where snowmobiles are unloaded, fueled, started, and warmed before excursions are begun. Wyoming State Highway 130 through the Snowy Range is closed west of this site to automobile traffic during the winter season; and the road right-of-way is designated Snowmobile Trail U. About 2 km from the trailhead, another trail branches north (Snowmobile Trail O) following the snow-covered

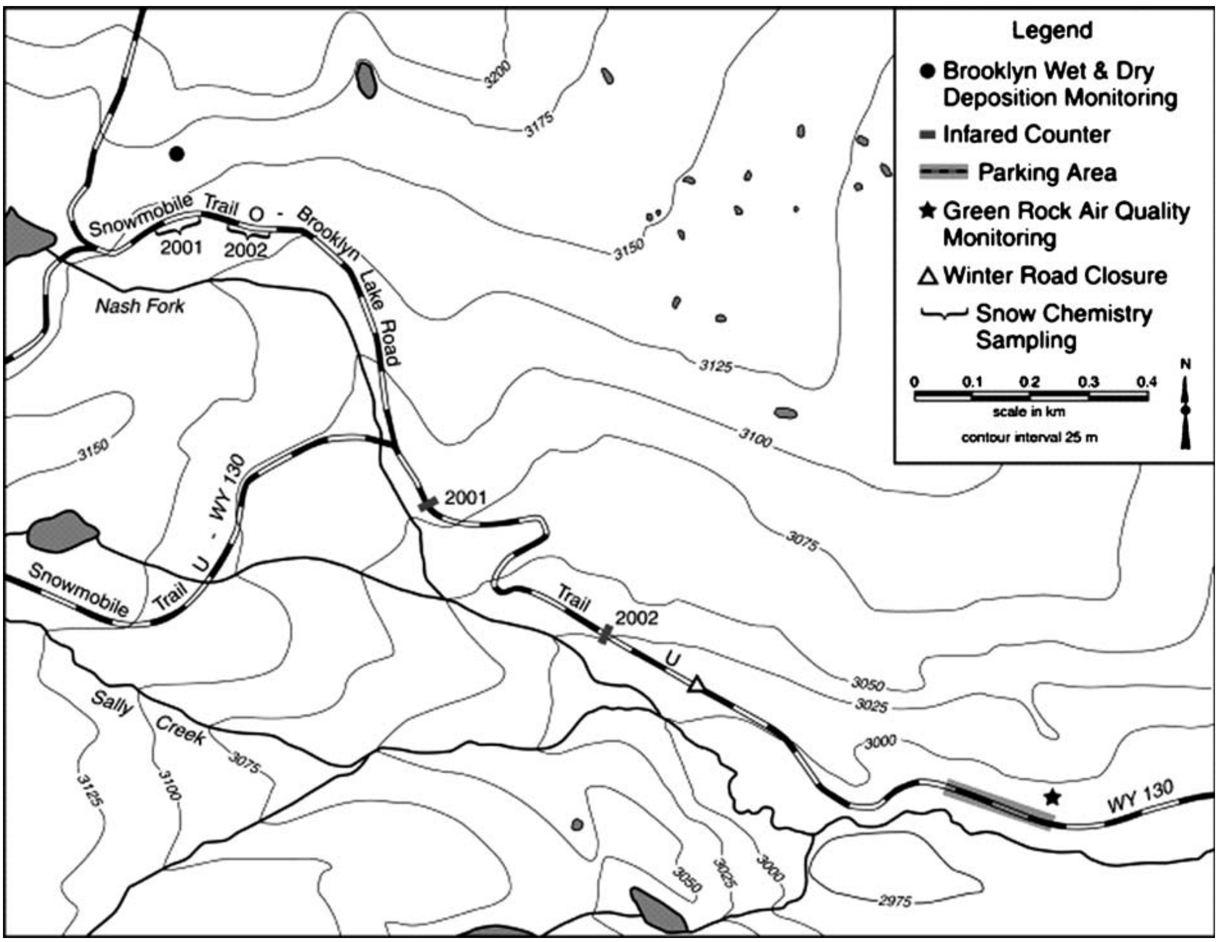

Fig. 1 Location of air quality monitoring and snow sample collection, Medicine Bow National Forest, Snowy Range, Wyoming. The CASTNet CNT169 is located at the Brooklyn Wet and Dry Deposition Monitoring site

Brooklyn Lake Road, a gravel Forest Service road. Trail O continues along the Brooklyn Lake Road except for a small off-road section just southwest of the Brooklyn Deposition Monitoring site (Fig. 1), then through the GLEES and along the summer hiking trail to Sheep Lake and beyond.

Air quality was monitored from winter 2000–2001 through the winter of 2001–2002, including the summer between the two winter seasons. A 2.5× 3 m insulated building to house meteorological and air quality instrumentation was installed near the Green Rock Picnic Area trailhead (Fig. 1). Although this site was selected for monitoring as a worse-case scenario where maximum pollution concentrations would occur, the sensors were not located directly on the roadway. The monitoring building was located about 15 m north and 5 m above the roadway to access a nearby electric power source. Air quality monitored included continuous sampling of concentrations of CO, NO_x, NO, and O_3. The sample intake was located 3.7 m above the ground, and 1.3 m above the top of the instrument building. CO was monitored using a Thermo Environmental Instruments 48C. Two monitors were used for NO_x and NO, a Monitor Labs 8840 and a Thermo Environmental Instruments 42S. The Thermo Environmental Instruments 42S monitor utilizes a low concentration range for monitoring of very low NO_x values, and thus is not a standard EPA reference or equivalent method. NO_2 was calculated from the NO_x and NO output data. O_3 was monitored using a TECO Model 49. The TECO CO and O_3 and the Monitor Labs NO_x instruments were EPA equivalency instruments. Nighttime zero and span calibration checks were conducted sequentially each day beginning at midnight for the Monitor Labs NO_x monitor, followed by the TECO NO_x monitor, then the TECO CO monitor. The zero calibration for the O_3 monitor was also checked every 24 h.

Air quality signals at the Green Rock staging area reflect all sources of pollutants, including snowmobiles and automobiles (primarily SUVs or pickup trucks) pulling snowmobile trailers. The air quality monitoring started late in the winter season of 2000–2001, Therefore, for CO, NO_x, and O_3 the 2000–2001 winter season was primarily used to test air quality monitoring equipment and calibration protocols.

Mass of 10 μm particulate matter (PM_{10}) was monitored for 24-h periods every 6 days following standard PM_{10} monitoring protocols, using a General Metal Works, Inc. particulate monitor. Air quality data were recorded on a Campbell 23X data logger every 10 s with 30-min averages calculated and saved to a data storage module.

Wyoming and national ambient air quality standards exist for particulate matter, carbon monoxide, nitrogen oxides, ozone, and other pollutants, and are listed on the Wyoming Department of Environmental Quality, Air Quality Division web site.[3] However, since the monitoring building in this study was not sited according to state or federal air quality monitoring standards (it was sited near a roadway and near trees to monitor air quality specifically at this snowmobile staging area roadway site), the data from this study cannot be directly related to ambient air quality standards. Data presented are only an indication of pollutant levels at the site for comparison with snowmobile activity. Nevertheless, the data can indicate whether air quality at this site warrant further monitoring following EPA siting protocols.

Snowmobile numbers were counted at a point on the main trail just west of the staging area using a Trail Master automatic infrared sensor. The sensor was aimed across the trail at about 60 cm height above the snow surface. The sensor height was adjusted accordingly as the snowpack depth accumulated. Data were downloaded every Tuesday for subsequent analysis.

Data were analyzed by comparing weekend (1200 Friday–2359 Sunday) with weekday (0001 Monday–1159 Friday). Seasonal differences were analyzed by comparing spring, summer, and fall (SSF, June 19–November 10, 2001, and April 21–Jun 18, 2002) with winter (WIN, November 11, 2001–April 21, 2002). These seasons were related to snowmobile season rather than meteorological season as defined in Zeller et al. (2000a, b).

Standard meteorological instrumentation was installed above the monitoring building for monitoring temperature, relative humidity, wind speed, and wind direction. Sensors were mounted 5 m above the ground. Meteorological data were recorded on a Campbell 21X data logger at 5-s intervals with 1 and 24 h averages calculated and saved to a data storage module. Data were downloaded weekly for processing.

[3] http://deq.state.wy.us/aqd.htm#Regulations.

The snow chemistry study was conducted on Trail O over Brooklyn Lake Road (Fig. 1). Snow samples were collected in February and April of 2001, to capture the early and late season snowpack, at a site along the snowmobile trail near the Saint Alban's Chapel, but over the Brooklyn Road (Fig. 1), for chemical analysis of Acid Neutralizing Capacity (ANC), pH, cations and anions and snow density (April only). Of particular interest were nitrate, sulfate, and ammonium. Snow samples were collected from three transects at least 40 m apart along the snowmobile trail, at various distances perpendicular from the trail, using a Federal snow sampler to collect from the top to the bottom of the snowpack. Snow depth was also recorded. All samples were collected in open areas and sampling near trees was avoided. It could not be verified that snowmobiles had not passed over the sampling locations even at 40 m from the trail at the sites sampled. Off-trail data were combined for comparison with on-trail data. In 2002, snow samples were collected February, March, April, and May at three points along the trail near the same location sampled in 2001 (Fig. 1). To increase replication in 2002, six samples were collected on and six off the trail at three sites rather than collecting samples along a transect perpendicular from the trail at each site as in 2001. Care was taken in 2002 to avoid areas off-trail where snowmobile activity was evident. For both years, all samples were weighed to determine snow water equivalent (SWE) and transferred to Ziploc bags, shipped to the lab frozen, and melted for chemical analysis of acid neutralizing capacity (ANC), pH, conductivity, cations (Ca^{+2}, Mg^{+2}, K^{+1}, Na^{+1}, NH_4^{+1}) and anions (NO_3^{-1}, SO_4^{-2}, Cl^{-1}, PO_4^{-2}).

Day of week (weekend vs weekday) and seasonal differences in all variables were evaluated using PROC MIXED, SAS Version 8 (SAS Institute 2000). The sampling unit was the 24-h mean of the response variable; all models used the residual maximum likelihood (REML) as the estimation method and specified a diagonal covariance structure. All models except those used for snowmobile counts incorporated two fixed effects (a first variable indicating weekday or weekend, and a second indicating season) and a term for the interaction of the two variables. The model for snowmobile counts was a one-way model using only the weekend/weekday variable. Statements of significant differences in the text indicate statistical significance at the 5% confidence level.

Results and discussion

Snowmobile counts

The counter worked reasonably well for providing rough temporal comparisons of snowmobile presence at the site; but was not accurate enough to give reliable snowmobile numbers. A one time hand count indicated that the infrared sensor counted less than half of the actual number of snowmobiles passing the sensor location. In addition, it was observed that a small number of snowmobiles passed behind the sensor, and two snowmobiles passing side by side were counted as one.

Given these numerous caveats and the high variability in the count data, the numbers recorded by the infrared sensor are not considered an accurate count of the number of snowmobile units. Nevertheless, the infrared sensor counts of approximately 200–300 daily snowmobile passes weekday and approximately 600 weekends suggest higher snowmobile activity during weekends. The number of snowmobiles also appeared to be higher weekends based on our visual observations and higher numbers of parked vehicles and snowmobile trailers weekends at the trailhead. Kado et al. (2001) have documented lower numbers midweek than weekend at the West Entrance to Yellowstone National Park. Other counting methods should be explored for counting snowmobiles, including ground mounted under snow motion or magnetic sensors.

Air quality

Because of the late winter start of this study, NO_x, CO, and O_3 air quality data were sparse for much of the 2000–2001 snowmobile season and are not reported here. Nevertheless, preliminary observations indicated that for late winter 2001 NO_x from the Monitor Labs and the TECO instruments tracked closely and no weekend/weekday differences for O_3 were evident. CO was not monitored in 2000–2001. Results of PM_{10} for 2001, and CO, NO_x, O_3, PM_{10}, and $PM_{2.5}$ for the winter of 2001–2002 are discussed.

Carbon monoxide

CO was significantly higher weekends than weekdays, and significantly higher in winter than in summer (Fig. 2). CO was low during the summer, with individual readings seldom above 1 ppm. The maximum CO concentrations recorded during this study were 9.9 ppm hourly average and 1.6 ppm 8-h average. A weekend signal was apparent in summer and winter, perhaps reflecting increased recreational weekend automobile traffic in summer, and increased snowmobile traffic in winter. Higher CO in winter than summer reflects snowmobiles starting at the staging areas and/or motor vehicles towing snowmobile trailers at the parking area. Vehicles were seldom parked along the road at the site in summer, but frequently parked here in winter to unload and start snowmobiles. The common source of pollutants during the summer was light duty motor vehicles traveling the highway, and the lower summer CO values reflect emission controls required on those vehicle.

Nitrogen oxides

There were significantly higher concentrations of NO_x, NO, and NO_2 at the site during the weekend in winter, suggesting a signal from snowmobile activity (Fig. 3). NO_x concentrations seldom exceeded 2.5 ppb. The mean NO_2 value for the entire study period (357 days) was 1.5 ppb, with the maximum 30-min value at 19.8 ppb. NO_2 and NO_x were higher in summer than in winter, reflecting general seasonal differences in nitrogen oxides at the site, but no weekend/weekday differences were evident during summer (Fig. 3). Higher mean daily maxima of NO, NO_2, and NO_x concentrations also occurred during the weekends in the winter (data not shown). The higher weekend concentrations of NO_x and CO is logical given the expected visitor use patterns, although it is the opposite of the tendency noted in a suburban setting by Blanchard and Tanenbaum (2006).

Ozone

Ozone concentrations show little diurnal change in the winter, and closely track temperature in the summer. Mean O_3 concentration appeared to be slightly (but not significantly) higher in winter (50 ppb) than in summer (45 ppb), but there were no significant weekend/weekday differences in O_3 winter or summer (data not shown). Suggested higher mean concentrations in winter might reflect the lack of NO_x scavenging of O_3 thus higher minimum O_3 concentrations in winter (Wooldridge et al. 1997). Maximum ozone concentrations appeared to be slightly (but not significantly) higher in summer than winter, perhaps reflective of higher summertime temperatures and higher solar radiation for photochemical generation of O_3; but mean daily maximum O_3 concentrations never exceeded 60 ppb. The

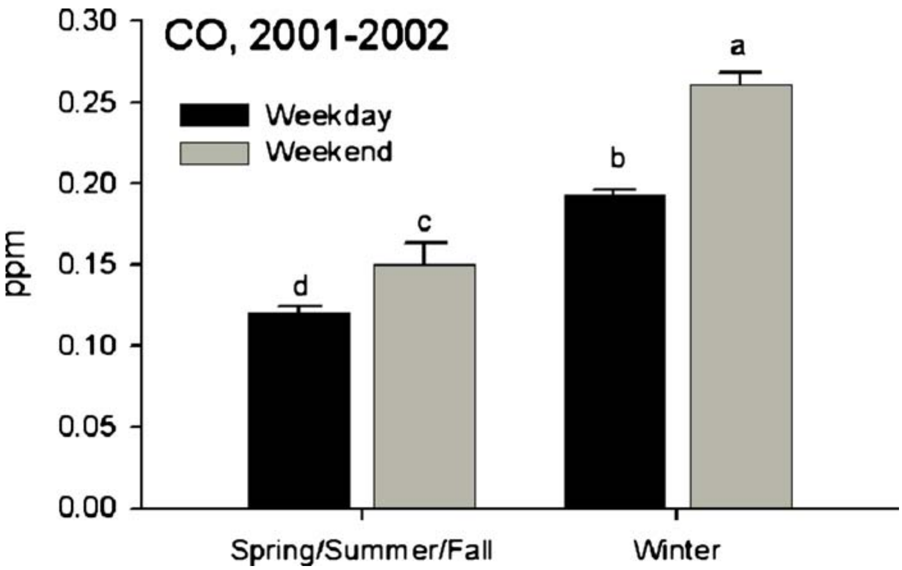

Fig. 2 Daily mean carbon monoxide at the Green Rock snowmobile staging area. *Vertical lines on each bar* indicate ± one standard error of the mean. *Different letters* indicate significant ($p<0.05$) differences in CO concentration

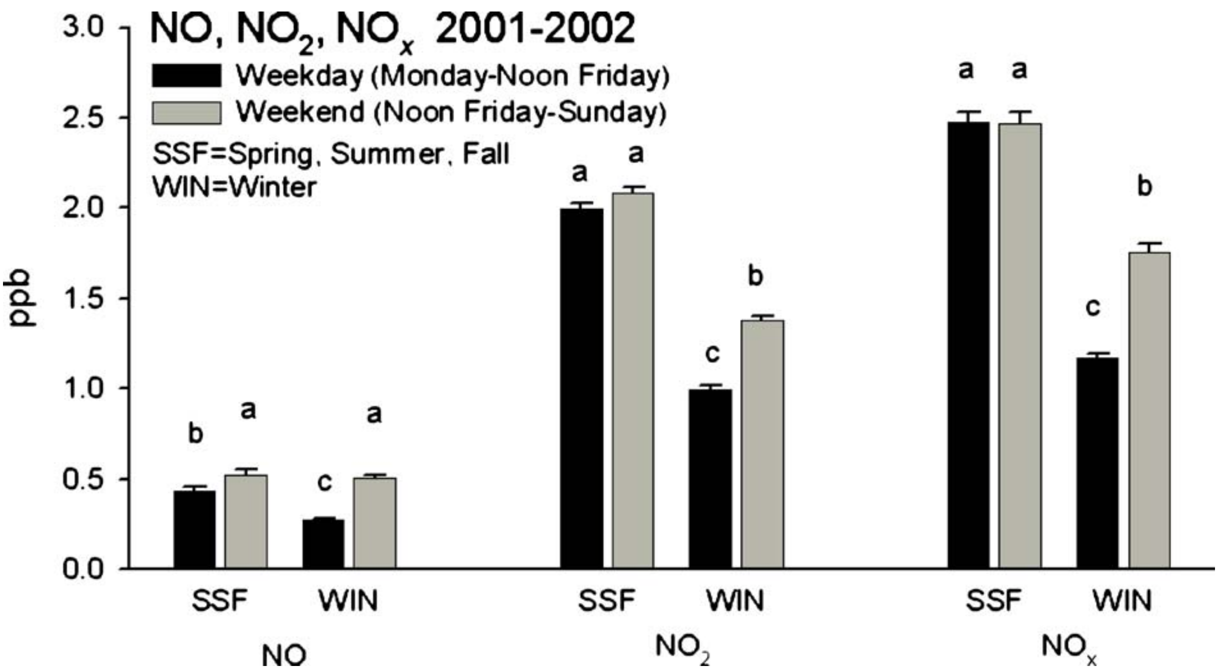

Fig. 3 Nitrogen oxides at the Green Rock snowmobile staging area. *Vertical lines on each bar* indicate ± one standard error of the mean. *Different letters* indicate significant (p<0.05) differences in NO, NO_2, or NO_x concentration

relationship of O_3 to NO_2 is not evident from the data, although chemically O_3 and NO react to form NO_2. O_3 values seldom reach zero at this remote site (Wooldridge et al. 1997). A comparison of the winter O_3 values at the snowmobile trailhead and at the CASTNet site (CNT169) about 2 km away (Fig. 1) found the difference between the two sites to be small, an average of 0.75 ppb less at CNT169.

Particulate matter, PM_{10} mass

PM_{10} was low, generally less than 10 μg/m^3 at the site, but appeared to be higher in the summer than winter (Fig. 4). Although differences between winter and summer were significant in 2001, the apparent winter/summer difference in 2002 was not statistically significant. PM_{10} would be expected to be higher in summer than winter, as less land surface is snow covered, and greater surface area is available for wind erosion and transport to the site during the summer. The use of unpaved rural roads and greater automobile traffic in summer would also contribute to higher airborne particulates. There apparently is little weekend/weekday differences in PM_{10} at the site, but monitoring protocols (once every 6 days) allowed considerably fewer weekend samples for comparison.

Meteorology

Temperature and relative humidity followed typical diurnal patterns for this area. Winter temperatures seldom exceeded 0°C. Wind direction is predominantly from the west. Wind speed, an important factor in pollutant dispersion, was considerably higher in winter than in summer.

Pollutants and wind

The air quality monitoring station was located north of the road on a slope facing toward the road, and the prevailing wind direction was from the west and west south west, so it is likely that some of the pollutant emissions from the roadway were not detected. Some additional dispersion of roadway pollutants occurred before reaching the intake located about 9 m above the road surface. Data analysis suggests that indeed when the winds were from the southerly direction (110.5–247.5°) where the road was located, concentrations of CO were higher than when winds were

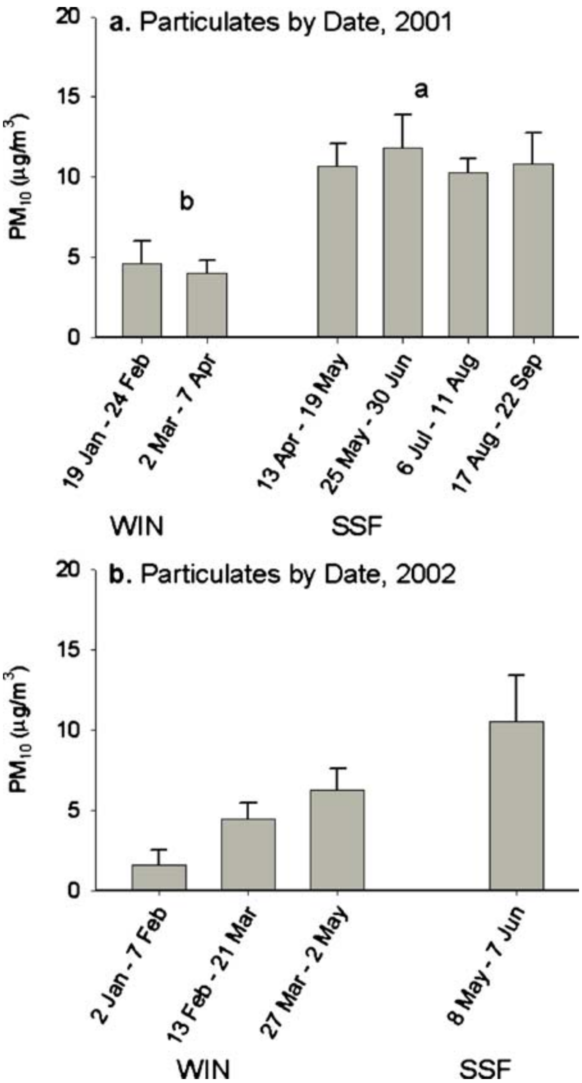

Fig. 4 Particulate matter (10 µ size) at the Green Rock snowmobile staging area. *Vertical lines on each bar* indicate ± one standard error of the mean. *Different letters* indicate significant ($p<0.05$) difference between winter (WIN) and spring/summer/fall (SSF) PM_{10} for 2001. There were insufficient data to evaluate seasonal difference in 2002. There were no significant differences between weekend/weekday for 2001 or for 2002

from the west through east direction (270–360 and 0–90°) (Fig. 5).

O_3 also was higher when the winds were from a southerly direction (Fig. 5). Wind velocities were significantly higher when winds were from the west and west south west (Fig. 6). Exposure of the monitoring building was more open in this direction than from the more northerly directions where trees and the uphill slope may absorb O_3 before it could reach the sensor. O_3 is highly reactive with plant tissue and is expected to be lower within the canopy where it can more easily be absorbed. O_3 was also lower when wind velocities were lower. Relating measured levels of ozone to local sources of pollution (i.e., snowmobiles) is somewhat problematic in any event, since ozone is a secondary pollutant not directly emitted from point sources. Assessment of local sources of this pollutant can be compounded by regional generation and transport of O_3 (e.g., Blanchard and Tanenbaum 2006), but we do not suspect that local generation of O_3 had a significant effect on measurements at the Green Rock site.

NO and NO_x concentrations were less when winds were from the west and west south west (corresponding to highest wind speeds; Fig. 6) compared to winds from the east and northerly directions (lower wind speeds). NO_2 and NO_x concentrations were lower when winds velocities were higher, suggesting greater dispersion under high winds. Data presented in Fig. 5 are for yearly means, but there was a significant seasonal effect on pollutant concentration and wind direction (data not shown). Since W and WSW winds were the strongest and most frequent (Fig. 6), it follows that pollutant dispersion (and hence lower measured levels of pollutants) would be greatest when winds were from this direction.

Exceedances of ambient air quality standards

This study was not designed to compare the air quality data to federal or state ambient air quality standards. Nevertheless, NO_2, CO, O_3, and PM_{10} concentrations monitored at this site appear to be well below the threshold levels for exceedance of National or Wyoming Air Quality Standards for these pollutants regardless of snowmobile activity. However, higher concentrations of air pollutants were detected during weekends when snowmobile activity was higher. The results of our study differ from those examining gaseous snowmobile pollution at Yellowstone National Park and elsewhere. For example, Kado et al. (2001) measured 4-h average concentrations of CO in excess of 6 ppm; another study (Ray 2005) reported CO concentrations nearly in violation of the NAAQS 8-h standard of 9.0 ppm at the West Yellowstone park entrance for the winter of 1998–1999. The highest 4-h average observed (30 Decem-

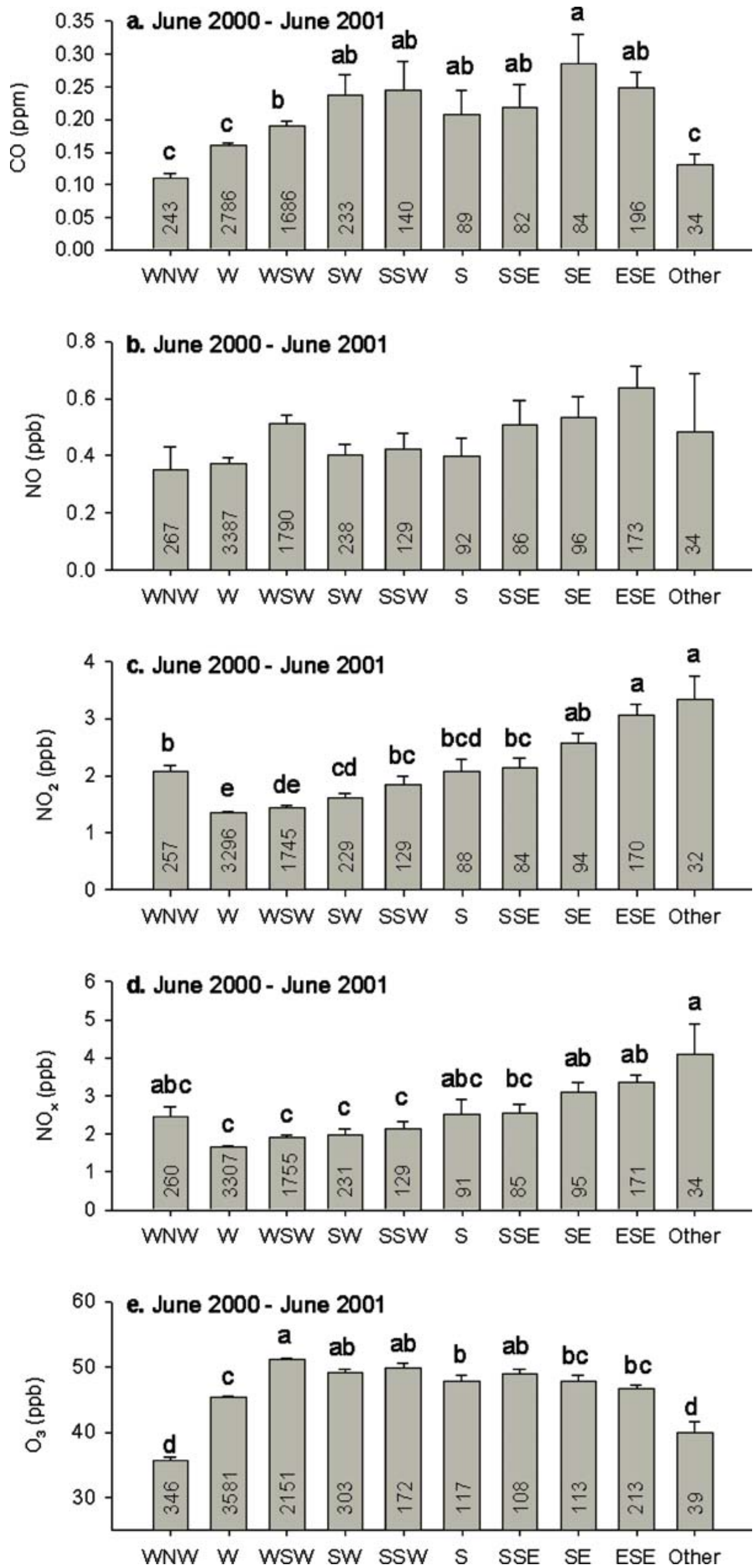

Fig. 5 Gaseous air pollutant by wind direction. *Numbers on bars* indicate number of samples available for analysis. Note there were few values for wind direction "other." These are wind directions other than those indicated on the *x*-axis. *Different letters* indicate significant ($p<0.05$) differences in gaseous pollutant by wind direction. *Vertical lines on each bar* indicate ± one standard error of the mean

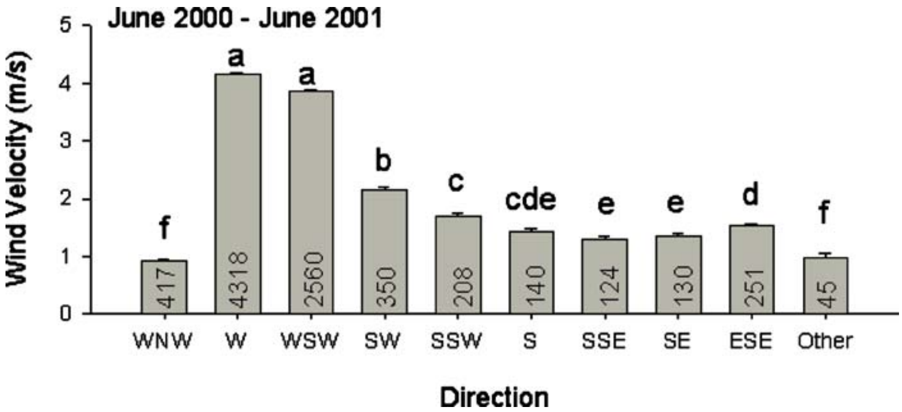

Fig. 6 Wind velocity and wind direction at the Green Rock air quality monitoring station *Vertical lines on each bar* indicate ± one standard error of the mean. *Different letters* indicate significant ($p<0.05$) differences in wind velocity; *numbers* indicate sample size

ber 2001) at Green Rock was 2.64 ppm CO. Green Rock experienced no 4-h average CO concentration greater than 1.7 ppm on any other date during the remainder of the study. The Green Rock snowmobile staging area was selected as a worst-case site, and concentrations were expected to be much lower away from the Green Rock site where snowmobile activity was significantly less.

Substantial differences exist in site characteristics and meteorology between Green Rock and the monitoring sites in West Yellowstone. The West Yellowstone site is located in a broad river valley at relatively low elevation (2,035 m) and experiences periods of light or calm winds. Kado et al. (2001) reported a maximum average wind speed of only 1.32 m/s in the course of their test. Green Rock's location (a hillslope at 2,985 m) and nearly constant winds (Fig. 6) were conducive to effective pollutant dispersion and dilution.

Snow chemistry and density

Examination of snow chemistry and snow density data indicate little difference between the trail and off-trail samples for 2001 (data not shown, concentrations similar to 2002). The trail where the snow samples were collected in 2001 is wide, and it appeared no points along the sampling transects were free of snowmobile passes. When care was taken in 2002 to sample where off trail sites had no apparent snowmobile traffic, data suggest significant on and off trail differences in snow chemistry for most cations (Fig. 7) and some anions (Fig. 8), and for snow density (significantly higher on the trail, data not shown). There was no snowmobile traffic on the trail in May. ANC on-trail/off-trail differences were significant only for April. There were no significant differences in NO_3^- concentration on or off the trail, suggesting no effect of snowmobiles on nitrate deposition at the site. These data agree with those of from Yellowstone National Park where nitrate concentrations in snow were relatively unaffected by snowmobile traffic, but ammonium and sulfate concentrations were higher in snow on the trail (Ingersoll 1999).

Seasonal changes in chemistry were evident for most analytes (Figs. 7 and 8). Early season highs in Na^+, Ca^{2+}, NO_3^-, and Cl^-concentrations, and early season low for ANC, were particularly evident. Since the snowmobile trail is routed over a gravel forest road, chemicals could have originated from the road surface even though sample collection protocols strictly avoided sampling the ground surface and bottom of the snowpack/roadway interface. Although this forest road has never been salted, vehicles travel from Highway 130 to this forest road during the summer. Highway 130 is 1 km south of the sample collection site, and is heavily salted east of the Green Rock area in the winter.

Conclusions

(1) It was evident that more snowmobiles were present at the site weekends than weekdays, but the infrared counter proved inadequate for providing accurate snowmobiles counts.
(2) There were significant differences in air quality between weekends and weekdays. Data show significantly higher concentrations on weekends

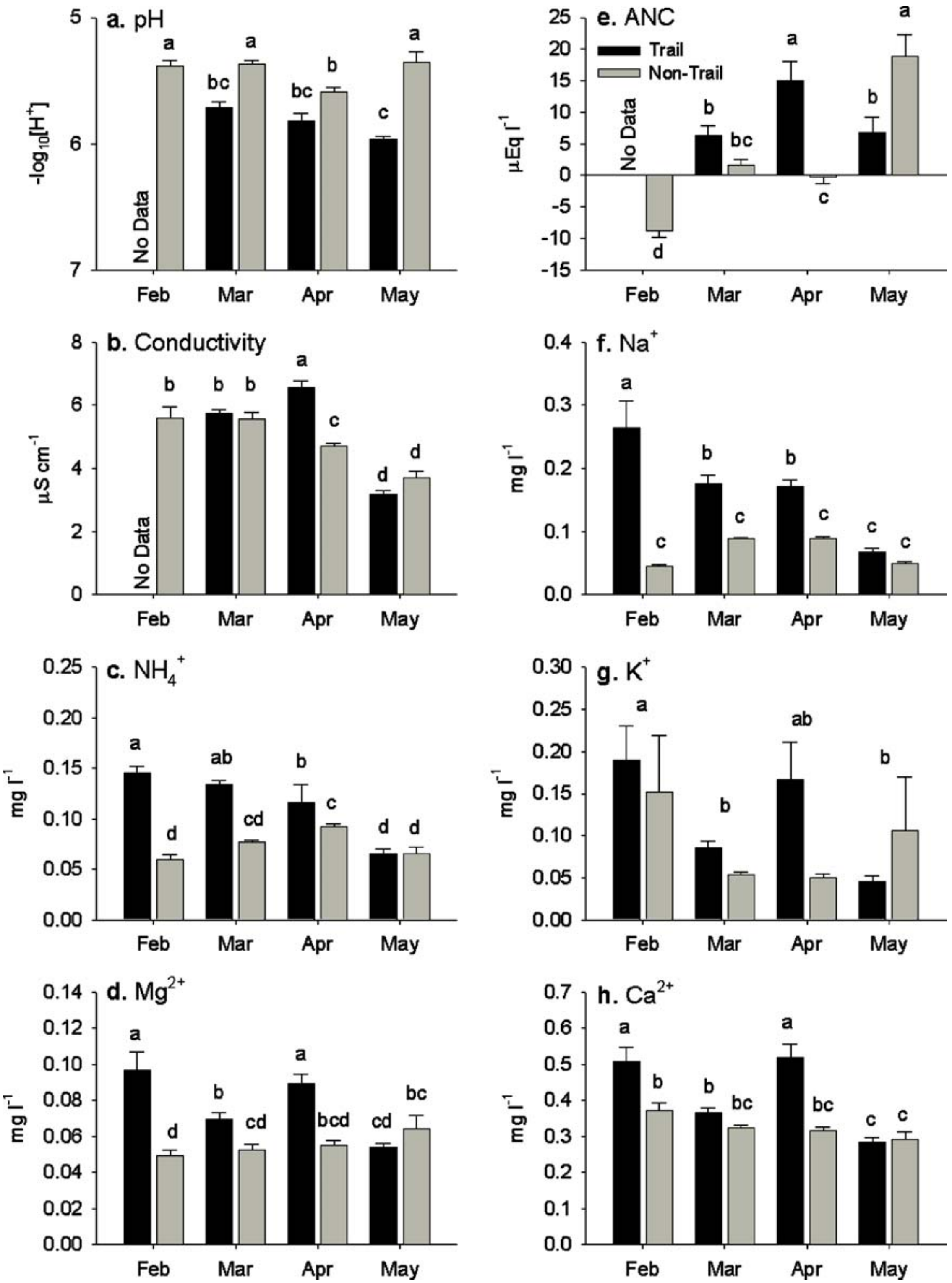

Fig. 7 pH, conductivity, and cation snow chemistry on and off the snowmobile trail, 2002. *Vertical lines on each bar* indicate ± one standard error of the mean. *Different letters* indicate significant ($p<0.05$) differences

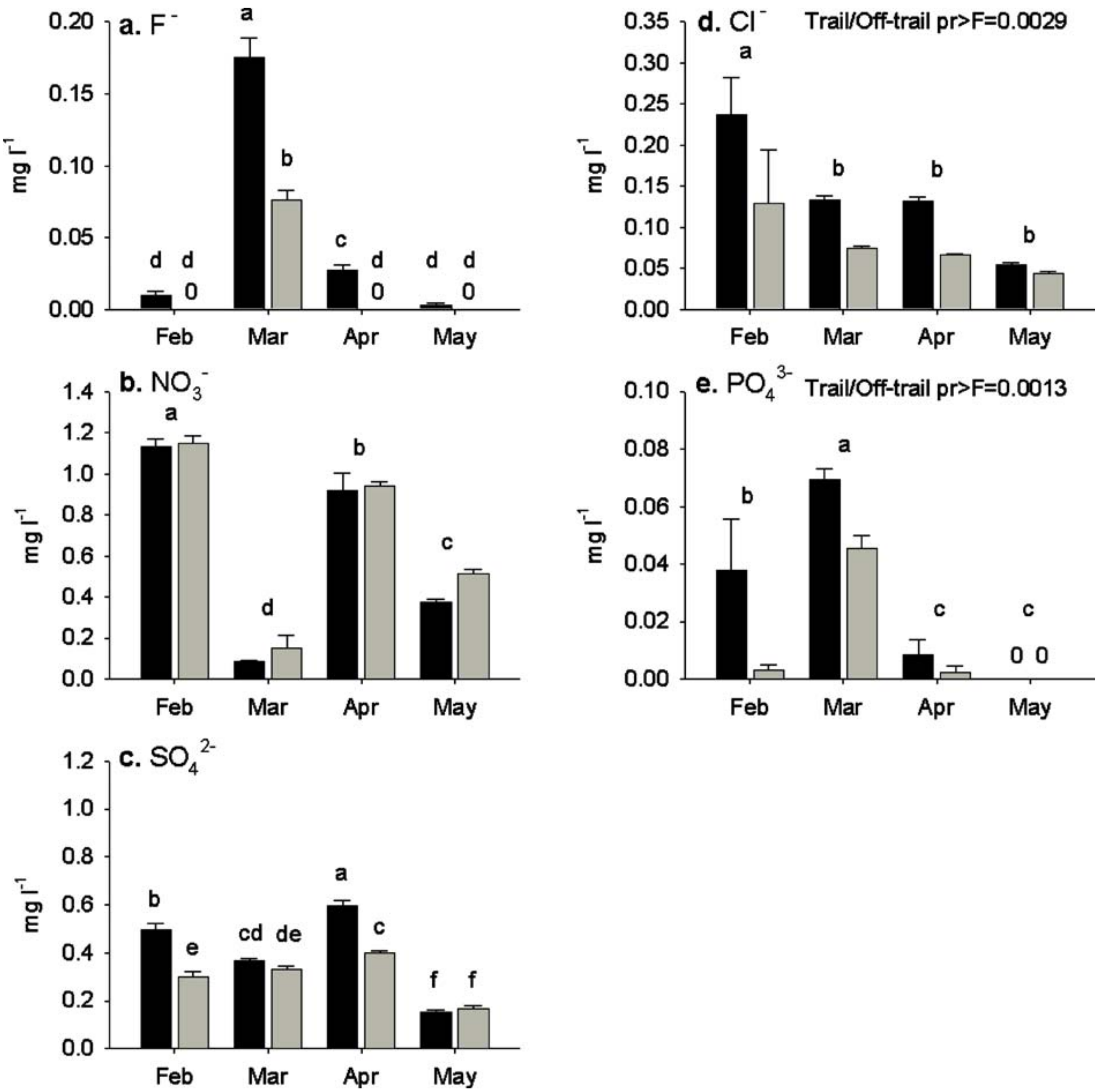

Fig. 8 Anion snow chemistry on and off the snowmobile trail, 2002. *Vertical lines on each bar* indicate ± one standard error of the mean. *Different letters* indicate significant (p<0.05) differences in anion chemistry

in winter when more snowmobiles were present for CO, NO_2, NO, and NO_x, but not for O_3. Concentrations of CO and NO were also higher weekends than weekdays during summer. Mean daily maxima of NO, NO_2, and NO_x occurred weekends during the winter. The data suggest that although NO_x concentrations were generally low, increased weekend concentrations resulted from snowmobile activity.

(3) Seasonal differences were evident in air chemistry, specifically for CO, NO_2, and NO_x, but not for NO or O_3. NO_2 and NO_x were higher in summer than winter, while CO concentrations were higher in winter than summer. Nevertheless, air pollutant concentrations were generally low both winter and summer, and were considerably lower than exceedence levels of NAAQS.

(4) PM_{10} was lower in winter than summer, and there were no significant weekend/weekday differences.

(5) CO and O_3 concentrations were higher, and NO_x and NO_2 were lower, when the wind was from the south. The monitoring was conducted just north of the roadway. O_3 was lower and NO_2 and NO_x were higher when wind velocities were lower. The data suggest that under prevailing wind conditions air pollutant concentrations on the roadway were likely higher than those detected by our monitoring sensors. Nevertheless, an air pollution signal was detected that could be related to snowmobile activity; but the pollutant concentrations were low and not likely to cause significant air quality impacts even at this high snowmobile activity site.

(6) Wind speed and physical site characteristics are probably the most important determinants of pollutant concentrations at the level of use described in most existing studies of snowmobile pollutants. There was greater dispersion of pollutants with high winds The open, high elevation Snowy Range site with high winds may be much less likely to experience pollutant levels at or near exceedance criteria than a (relatively) low-altitude site with somewhat restricted terrain and low wind speeds, (e.g., West Yellowstone).

(7) Snow chemistry was significantly different between on and off trail for some analytes when sampling was designed to collect from areas with or without snowmobile activity. Na^{+}, Ca^{2+}, Mg^{2+}, NH_4^{+}, $F^{-}$and SO_4^{2-} appeared to be higher on the trail than off, especially early in the season. The trail followed a roadway, which may have affected on-trail snow chemistry concentrations. There were no differences in NO_3^{-} on or off the trail. Snow density was higher on the trail than off.

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References

Atkin, O. K., & Collier, D. E. (1992). Relationship between soil nitrogen and floristic variation in late snow areas of the Kosciusko Alpine region. *Australian Journal of Botany, 40*, 139–149.

Bishop, G. A., Morris, J. A., & Stedman, D. H. (2001). Snowmobile contributions to mobile source emissions in Yellowstone National Park. *Environmental Science and Technology, 35*, 2874–2881.

Bishop, G. A., Stedman, D. H., Hektner, M., & Ray, J. D. (1999). An in-use snowmobile emission survey in Yellowstone National Park. *Environmental Science and Technology, 33*, 3924–3926.

Blanchard, C. L., & Tanenbaum, S. (2006). Weekday/weekend differences in ambient air pollutant concentrations in Atlanta and the southeastern United States. *Journal of Air & Waste Management Association, 56*, 271–284.

Bowman, W. D. (1992). Inputs and storage of nitrogen in winter snowpack in an alpine ecosystem. *Arctic and Alpine Research, 24*, 211–215.

Bowman, W. D., & Steltzer, H. (1998). Positive feedbacks to anthropogenic nitrogen deposition in Rocky Mountain alpine tundra. *Ambio, 27*, 514–517.

Bowman, W. D., Theodose, T. A., Schardt, J. C., & Conant, R. (1993). Constraints of nutrient availability on primary production in two alpine tundra communities, Abstracts. LTER all scientists meeting and international summit. September 18–24, 1993. Estes Park, CO. LTER Network Office, Seattle, WA.

Creel, S., Fox, J., Hardy, A., Sands, J., Garrott, B., & Peterson, R. (2002). Snowmobile activity and glucocorticoid stress responses in wolves and elk. *Conservation Biology, 16*, 809–814.

Eriksson, K., Tjärner, D., Marqvardsen, I., & Järvholm, B. (2003). Exposure to benzene, toluene, xylenes and total hydrocarbons among snowmobile drivers in Sweden. *Chemosphere, 50*, 1343–1347.

Fenn, M. E., Haeuber, R., Tonnesen, G. S., Baron, J. S., Grossman-Clark, S., Hope, D., et al. (2003). Nitrogen emissions, deposition, and monitoring in the Western United States. *BioScience, 53*, 391–403.

Finley, J. B. Jr. (1992). Surface and groundwater hydrochemistry in a snowmelt dominated catchment, Snowy Range, Wyoming, PhD Dissertation, Department of Geology and Geophysics at the University of Wyoming.

Hogan, A. W. (1972). Snowmelt delay by oversnow travel, *Water Resources Research, 8*, 174–175.

Ingersoll, G. P. (1999). Effects of snowmobile use on snowpack chemistry in Yellowstone National Park, 1998. U.S. Geological Survey Water-Resources Investigations Report 99-4148. Denver, CO.

Ingersoll, G., Turk, J., McClure, C., Lawlor, S., Clow, D., & Mast, A. (1997). Snowpack chemistry as an indicator of pollutant emission levels from motorized winter vehicles in Yellowstone National Park, p 103–113 in Proceedings, 65th annual meeting western snow conference, May 4–8, 197. Banff, Alberta Canada. Published by USDA Forest Service.

Interlandi, S. J., & Kilham, S. S. (1998). Assessing the effects of nitrogen depositon on mountain waters: A study of phytoplankton community dynamics. *Water Science and Technology, 38*(10), 139–146.

Irving, P. (ed) (1992). Acidic deposition: State of Science and Technology. summary report of the U.S. National Acid Precipitation Assessment Program. Washington, D.C.

Kado, N. Y., Kuzmicky, P. A., & Okamoto, R. A. (2001). Environmental and occupational exposure to toxic air pollutants from winter snowmobile use in Yellowstone National Park. final report. California EPA, California ARB, Sacramento, CA p 152.

Keddy, P. A., Spavold, A. J., & Keddy, C. J. (1979). Snowmobile impact on old field and marsh vegetation in Nova Scotia, Canada: An experimental study. *Environmental Management, 3*, 409–415.

Korfmacher, J. L., & Musselman, R. C. (2004). Long-term wet- and dry-deposition trends at the Glacier Lakes Ecosystem Experiments Site (GLEES). In: National atmospheric deposition program scientific symposium, September 21–25, 2004. Halifax, Nova Scotia. Abstract.

Kudo, G. (1991). Effects of snow-free period on the phenology of alpine plants inhabiting snow patches. *Arctic and Alpine Research, 23*, 436–443.

Musselman, R. (1994). The glacier lakes ecosystem experiments site, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report GTR-RM-249. Fort Collins, CO.

National Park Service (1995). *Ambient air quality study results – West Entrance Station,Yellowstone National Park*. Denver, CO: National Park Service.

Neumann, P. W., & Merriam, H. G. (1972). Ecological effects of snowmobiles. *Canadian Field-Naturalist, 86*, 207–212.

Pesant, A. R., Fernet, C., Belzile, L., & Dionne, J. L. (1985). Effects of snowmobile traffic on yield and botanical composition of forage stands in Quebec. *Canadian Journal of Plant Science, 65*, 543–552.

Placet, M. (1990). Emissions involved in acidic deposition processes. NAPAP Report 1. in volume 1. Emissions, atmospheric processes, and deposition. U.S. National Acid Precipitation Assessment Program. Washington, D.C. 1991.

Ray, J. D. (2005). Results from the Yellowstone National Park winter air quality study 2004–2005. USDI, National Park Service, Air Resources Division, Denver, CO. 64.241.25.110/yell/pdfs/winteruse/winteraqstudy04–05.pdf.

Reuss, J. O., Vertucci, F. A., Musselman, R. C., & Sommerfeld, R. A. (1995). Chemical fluxes and sensitivity to acidification of two high-elevation catchments in southern Wyoming. *Journal of. Hydrology, 173*, 165–189.

Rochette, E. A., Drever, J. I., & Sanders, F. S. (1988). Chemical weathering in the West Glacier Lake drainage basin, Snowy Range, Wyoming: Implications for future acid deposition. *Contributions to Geology, University of Wyoming, 26*(1), 29–44.

SAS Institute (2000). SAS/STAT User's Guide. SAS System for Windows, Version 8.02.

Schindler, D. W. (1988). Effects of acid rain on freshwater ecosystems. *Science, 239*, 149–157.

Snook-Fussel, L. (1997). Exposure of snowmobile riders to carbon monoxide. *Park Science, 17*, 1–10.

USDI (2000). Air quality concerns related to snowmobile usage in National Parks. USDI, National Park Service, Air Resources Division, Denver, CO. http://www2.nature.nps.gov/air/Pubs/pdf/yell/Snowmobile_Report.pdf).

Walker, D. A., Halfpenny, J. C., Walker, M. D., Wessman, C. A. (1993). Long-term studies of snow-vegetation interaction. *BioScience, 43*, 287–301.

Wanek, W. J. (1971). Observations on snowmobile impact. *Minnesota Volunteer, 34*(6), 1–9. (November–December 1971)

Williams, M. W., Baron, J. S., Caine, N., Sommerfeld, R., & Sanford, R. Jr. (1996). Nitrogen saturation in the Rocky Mountains. *Environmental Science and Technology, 30*, 640–646.

Wooldridge, G., Zeller, K., & Musselman, R. (1997). Ozone concentration characteristics at a high-elevation forest site. *Theoretical and Applied Climatology, 56*, 153–164.

Zeller, K., Harrington, D., Riebau, A., & Donev, E. (2000a). Annual wet and dry deposition of sulfur and nitrogen in the Snowy Range, Wyoming. *Atmospheric Environment, 34*, 1703–1711.

Zeller, K., Harrington, D., Fisher, R., & Donev, E. (2000b). Determining atmospheric deposition in Wyoming with IMPROVE and other national Programs. USDA Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-52, p 34.

EFFECTS OF WINTER RECREATION ON WILDLIFE OF THE GREATER YELLOWSTONE AREA: A LITERATURE REVIEW AND ASSESSMENT

Greater Yellowstone Winter Wildlife Working Group
Greater Yellowstone Coordinating Committee

October 1999

EFFECTS OF WINTER RECREATION ON WILDLIFE OF THE GREATER YELLOWSTONE AREA: A LITERATURE REVIEW AND ASSESSMENT

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Cover photo courtesy of the National Park Service.

Contents

PREFACE

This publication is a cooperative project of the Greater Yellowstone Coordinating Committee (GYCC) and was undertaken at the request of the Greater Yellowstone Winter Visitor Use Management Working Group (Working Group). Because the Working Group felt that the effects of winter recreation on wildlife had not been adequately addressed, the Winter Wildlife Working Group (Wildlife Group) was formed in December 1996. Twenty-six biologists and resource managers from the Forest Service, National Park Service, the states of Montana, Idaho, and Wyoming, and private organizations were invited to participate; 18 submitted papers.

The Wildlife Group first met in December 1996. We commissioned Jim Caslick, Ph.D. (Caslick 1997), retired wildlife biology faculty of Cornell University, to update an annotated bibliography on the effects of winter recreation on wildlife commissioned by Grand Teton National Park in 1995 (Bennett 1995). We examined these bibliographies, an additional bibliography supplied by the Biodiversity Legal Foundation (1996), and independent sources to address impacts to wildlife species and issues of concern.

This document is only the first step in addressing the effects of winter recreation on wildlife. The short time frame allotted for developing the issue statements did not allow for original research, though clearly more research is needed on this important topic. New information is also coming to light concerning the effects of two-cycle engines on air and water quality and the deposition of heavy metals in the snowpack. This new information is not included in this document. Additionally, there is no cumulative impacts analysis in this document, as that was beyond the scope of this effort.

We hope that this document will be useful to managers, biologists, and scientists as they manage and further explore the effects of winter recreation on the environment.

LITERATURE CITED

Bennett, L. E. 1995. A review of potential effects of winter recreation on wildlife in Grand Teton and Yellowstone National Parks: a bibliographic database. Report to the National Park Service in cooperation with the University of Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, Wyoming, USA. Available from Yellowstone National Park.

Biodiversity Legal Foundation. 1996. Report and formal comments on the current and potential adverse impacts of winter recreational use in Yellowstone National Park and the winter use management planning process by the U.S. National Park Service. Boulder, Colorado, USA.

Caslick, J. W. 1997. Impacts of winter recreation on wildlife in Yellowstone National Park: a literature review and recommendations. Report to the National Park Service, Yellowstone National Park, Wyoming, USA. Appendix I, this document.

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The project is the result of many hours of hard work by federal, state, and private biologists from throughout the Greater Yellowstone Area. Contributors took time from their busy schedules to research, write, and review the individual chapters, often volunteering their time and expertise. We are grateful for their effort and dedication.

Tom Olliff, Kristin Legg, and Beth Kaeding edited this report. Christy Hendrix and Tami Blackford assisted with technical editing. In addition, Tami completed document layout.

Finally, this project would not have been possible without the financial and moral support of John Sacklin, Chief, Planning and Compliance, Yellowstone National Park.

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INTRODUCTION

Since the first snowmobiles entered Yellowstone National Park in 1963, the number and types of winter recreationists have steadily increased. While media attention has focused on Yellowstone National Park, winter recreation on public lands throughout the Greater Yellowstone Area (GYA) has increased as well, for example snowmobilers in the Lionshead/Two-Top, Island Park, and Cooke City areas; skiers around Cooke City and Teton Pass; and snowshoers, dog sledders, and resort skiers throughout the ecosystem. Many of these activities have experienced explosive growth in the last decade.

In 1990, Yellowstone and Grand Teton national parks issued the *Winter Use Plan* for the two parks following public involvement and an environmental assessment. At the time, winter visitation in the parks was about 123,000 visitors. The plan forecast that winter use of the parks would not increase quickly and would not reach 140,000 (the high projection) for 10 years. However, that use level was reached by the 1992–93 winter, and, as directed by the plan, the parks began to address use levels by developing a process to assess visitor use.

Because winter use of the parks is only a portion of the winter use that occurs in the GYA, the other members of the Greater Yellowstone Coordinating Committee (GYCC) shared many of the same concerns of park managers. In April 1994, the GYCC chartered a team made up of staff from Yellowstone and Grand Teton national parks and Gallatin, Targhee, Shoshone, Bridger–Teton, Custer, and Beaverhead–Deerlodge national forests to study winter visitor use issues and to develop an assessment of use. This assessment, titled *Winter Visitor Use: A Multi-Agency Assessment*, showed that human use is not only increasing, but it is also expanding into areas that received little or no use in the past. Groomed snowmobile trails as well as some cross-country ski trails, particularly on national forest lands, are being expanded to accommodate this increase.

In 1995 the national parks conducted a scientifically based survey of its visitors. While many activities were listed as important, 93 percent of visitors to Yellowstone and 89 percent of visitors to Grand Teton rated wildlife as “very important” or “extremely important.”

Land managers, area residents, and the visiting public are concerned about the effect that the current levels of winter recreation may be having on the natural environment and wildlife. Human activities continue to expand into wildlife habitats. To minimize the impacts of these activities, wildlife managers need to be aware of the effects of these activities and to understand how to mitigate for them.

While much of the information in this document will be useful in areas beyond the GYA, the document does focus on many issues specific to this area. For example, one task accomplished through the visitor use management process was to describe the entire Greater Yellowstone Area in terms of Potential Opportunity Areas (POAs). Potential Opportunity Areas describe an area’s recreation potential, not necessarily its existing condition. The experiences range from those that are easily accessible and highly developed to those that are considered remote backcountry experiences. Complete descriptions of POAs can be found in Appendix II. How wildlife could be affected in various POAs is described in this review.

The purpose of this document is to provide guidelines for managing winter recreational use in the context of preserving wildlife populations. Several topics are discussed, including the current population status and trend of the individual species, relevant life history data, information on winter habitat use, summaries of studies on the influence of human activities on individual species in the winter, and the potential effects of specific winter recreational uses on those species. Papers that were peer-reviewed prior to the compilation of these papers are noted as such. All papers were subject to a joint review process by biologists and managers before being submitted to the final editing process.

MAMMALS

Photo courtesy of the National Park Service

EFFECTS OF WINTER RECREATION ON BIGHORN SHEEP

POPULATION STATUS AND TREND

Bighorn sheep (*Ovis canadensis*) were historically found throughout the mountains of western North America. Prior to the arrival of European man, their population is estimated to have been between 1.5 and 2 million. Bighorn sheep numbered fewer than 42,000 in 1974 (Wisthart 1978 in Reisenhoover et al. 1988). This decline was caused by competition with livestock, introduction of diseases, hunting, and loss of habitat during European settlement of the West (Buechner 1960, Keating 1982). With the establishment of management areas and hunting regulations, bighorn sheep have reoccupied some of their historic ranges, although populations have not reached pre-settlement sizes.

The creation of Yellowstone National Park in 1872 provided needed protection for the Rocky Mountain bighorn. In the early 1900s, fewer than 150 bighorn sheep were thought to exist in Yellowstone, and by 1912 managers estimated that 200 bighorns were in the park (Seton 1913, Mills 1937). Presently, bighorn sheep are found in limited areas of suitable habitat throughout the Greater Yellowstone Area (GYA); estimates of their numbers are included in Table 1. Larger populations are found along the eastern boundary of Yellowstone, with some populations having more than 1,000 animals.

Table 1. Estimated bighorn sheep population sizes in the Greater Yellowstone Area

Location	Estimated Number
Yellowstone National Park	240–325
Gallatin Mountains	50–65
Upper Yellowstone River, North of Yellowstone	60–75
Absaroka Mountains, Montana	130–175
Absaroka Mountains, Wyoming	4,190
Grand Teton Mountains	100–150
Madison Range	40–50
Gros Ventre Range	550
Wind River Mountains	900
Wyoming Range	75–100
Estimated Total	6,335–6,580

Today, bighorn populations continue to have some of the same problems that bighorns had when European settlers first arrived. In the winter of 1981–82, a chlamydia (a contagious infection of the eye) outbreak on the Mt. Everts winter range in Yellowstone reduced the bighorn population by more than 50 percent, from 487 to 159 (Meagher et al. 1992, Caslick 1993). Since that time the bighorn population has increased only slightly, and in 1996, 167 bighorns were observed on the same winter range surveyed before the outbreak (Lemke 1996).

Other populations in the GYA have declined as well (Jones 1994; Legg 1996; L. Irby, Montana State University, personal communication; S. Stewart, Montana Fish, Wildlife and Parks, personal communication; L. Roop, Wyoming Game and Fish Department, personal communication). The most recent decline was noted in the Madison Range population near Quake Lake, Montana, during the winter of 1996–97. It is believed that disease, predation, and human impacts such as illegal hunting, loss of habitat, and winter recreational use of winter ranges have contributed to these declines.

The loss of habitat and the fact that bighorns use traditional migration routes are the primary problems facing bighorn sheep today and are often mentioned as concerns for bighorn sheep management (Constan 1975; Horejsi 1976; Martin 1985; Reisenhoover et al. 1988; Environmental Protection, Fish and Wildlife Service 1993).

LIFE HISTORY

Adult ewes become mature at 2½ years. The breeding season occurs from November through late December, typically on winter range. Lambing occurs from mid-May through June, either near the winter range or during spring migration (May through July), and often along steep, precipitous cliffs. Fall migration is from October through December. The timing of both migrations depends upon weather and snow levels. Bighorn sheep typically remain in separate ewe/lamb and ram groups except during the rut. Males leave ewe/lamb groups between age 2–3.

HABITAT

Bighorn sheep utilize different ranges in the winter and summer, and they have an established migration route between these areas. The knowledge of these traditional ranges and migration routes is passed down from one generation to the next. By a bighorn's fourth year, it has learned its band's traditional home ranges and migration patterns (Geist 1971, Reisenhoover et al. 1988) and will use them the rest of its life. Any alteration of these habitats or routes could be detrimental for a population of bighorn sheep.

The amount of available winter range for Rocky Mountain bighorn sheep is usually more limited than the amount of summer range because of snow depth and spatial distribution. Because of this, winter range can be the critical habitat factor in the survival of bighorn sheep. Bighorns typically use lower elevation ranges in the winter because of low snow coverage in these areas, although some winter at higher elevations on windswept south-southwest facing slopes, usually above the thermocline (Oldemeyer et al. 1971). These higher elevation winter ranges can be problematic because bighorns have limited access to forage. The greater snow depths surrounding the small, available areas of forage habitat make movement from patch to patch difficult.

Habitat features that are important for bighorn sheep survival include the distance to escape terrain, slope, salt availability, elevation, aspect, forest cover, shrub availability, biomass and nitrogen content of palatable grasses, and snow depth/snow pack.

HUMAN ACTIVITIES

Protecting critical winter range by limiting human impacts is important for maintaining bighorn sheep in the GYA. Winter recreational use near or on bighorn sheep winter ranges may affect bighorns during the rut, during winter on the winter ranges that have limited amounts of available habitat, or in the spring during the lambing season.

The following types of recreational use could potentially affect bighorn sheep: hikers, wildlife photographers/observers, ice climbers, hunters, snowshoers, skiers, snowmobilers, sled dogs, and dogs on or off leashes. On ranges where bighorns are hunted, they are more sensitive to the presence of humans (Horejsi 1976). Any human activity on bighorn sheep winter range, especially within 100 yards of escape terrain, could affect bighorn sheep survivability.

Recreational activities may cause stress in bighorn sheep leading to increased heart rate and energy expenditures (MacArthur et al. 1982) and/or cause displacement from preferred foraging areas to less optimal habitat (Horejsi 1976, Hicks and Elder 1979). Bighorns typically forage during the warmest part of the day to minimize energy loss. If bighorns alter their foraging activities either spatially or temporally, they increase their exposure to predators, decrease the quality and quantity of food available to them, and increase their energy loss. Any decrease in energy intake or increase in energy expenditure as a result of human recreational activity may lead to the death of an already winter-stressed animal either directly by starvation or indirectly by lowering resistance to diseases or predation. The effects of human recreation can be considered an additive factor in lowering survivability in bighorns (Horejsi 1976).

MacArthur et al. (1982) showed elevated heart rates and fleeing behavior in bighorn sheep when approached by humans. This behavior was very apparent when humans surprised the bighorns or at any time dogs were present. The heart rate of the bighorns did not decrease with successive approaches, although if a predictable human behavior occurred (*i.e.*, direction and timing of approach), the bighorns became habituated and little response would be noticed except when a dog was present. If bighorns had been harassed earlier by a predator or human then the current harassment caused a greater response than normal.

In Montana, snowmobiles may have contributed to a decline in a bighorn sheep population in the Rock Creek drainage. The stress from the snowmobilers added to the natural stresses incurred during the winter (Berwick 1968). Human disturbance was also found to be a limiting factor for a population of bighorns in the Sierra Nevada Range. Herd size, human distance to the bighorns, and the elevational relationship of humans to bighorns were important factors in determining the reaction of bighorn sheep when approached by humans (Hicks and Elder 1979).

Boyle and Samson (1985) noted that rock climbing on or near bighorn sheep escape terrain can affect bighorns. Horejsi (1976) believes that improved access and more leisure time has increased recreational activities (from snowmobiling to walking the dog), which has resulted in more harm to wild bighorns. Because humans behave differently than natural predators (they often persist in following the bighorns to their escape terrain), they can displace bighorns from traditional areas.

There is the possibility that bighorn sheep may sometimes congregate near humans as a protection from predators, although the harassment by humans has to be less than the chance of predation. Along the Gallatin Ridge trail, there are two bighorn sheep summer ranges in the Hyalite and Tom Miner basins. There are many areas of bighorn habitat along the 30-mile-long ridge, but bighorn sheep were observed at locations having high visitor use relative to the rest of the area (Legg 1996). In winter, bighorns may not use the human/predator relationship to select habitat, as winter habitats are already limited to a few select areas.

POTENTIAL EFFECTS

Recreationists may cause increased stress for bighorn sheep during critical winter months, which may influence their survivability. Human use on the winter range during the breeding season could interfere with breeding by adding more stress to the rams and ewes. This may decrease the overall productivity of the population and increase the probability of predation and death.

Bighorns may abandon high quality winter range that is used heavily by humans, or they may limit their use to a small area near escape terrain. These limitations will decrease the available habitat used by bighorns or push them into areas with a greater potential for predation. If bighorns are unable to forage during the day because of recreationists, they will use more energy to forage when it is colder. Development on winter ranges or along migration corridors will decrease the already limited habitat available for bighorns.

During the lambing season ewes could be pushed into less optimal habitat, exposing the lambs to predators and environments with harsher weather.

Bighorn sheep in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(2) Primary transportation routes
(3) Scenic driving routes
(6) Backcountry motorized areas
(9) Backcountry nonmotorized areas
(10) Downhill sliding (nonmotorized)
(12) Low-snow recreation areas

MANAGEMENT GUIDELINES

- Human approach to the critical areas of bighorn habitat should be limited. A buffer zone should be established around bighorn sheep escape terrain.
- Human activities should be limited to roads or trails to minimize disturbance to bighorn sheep (MacArthur et al. 1982).
- Dogs should be prohibited on any bighorn sheep winter range (MacArthur et al. 1982).
- The remaining bighorn sheep habitat should be protected to ensure that migration corridors will remain intact and that traditional ranges are maintained.
- Special protection measures should be enforced during brief critical periods such as breeding, lambing, and severe winter weather (Boyle and Samson 1985).
- Activities such as ice climbing, wildlife photography/observation, and hiking that occur on lower elevation winter ranges should be monitored very closely. If there is any indication that bighorn sheep are being displaced either spatially or temporally, the activities should be stopped or managed to protect the bighorns.
- Skiing, snowmobiling, mountaineering, and snowshoeing will most likely only affect bighorn sheep wintering at higher elevations. The encounters between these recreationists and the bighorns may be infrequent enough that there would be little or no impact to the animals. However, if use increases at these higher elevation winter ranges, managers need to monitor the situation in order to prevent the loss of bighorn sheep on isolated winter ranges.

LITERATURE CITED

Berwick, S. H. 1968. Observation of the decline of the Rock Creek, Montana, population of bighorn sheep. Thesis, University of Montana, Missoula, Montana, USA.

Boyle, S. A., and F. B. Samson. 1985. Effects of nonconsumptive recreation on wildlife: a review. Wildlife Society Bulletin 13:110–116.

Buechner, H. K. 1960. The bighorn sheep in the United States; its past, present, and future. Wildlife Monographs Number 4.

Caslick, J. W. 1993. Bighorn sheep in Yellowstone: a literature review and some suggestions for management. National Park Service, Yellowstone National Park, Wyoming, USA.

Constan, K. J. 1975. Fish and Game Planning, Upper Yellowstone and Shields River drainages. Montana Department of Fish and Game, Environment and Information Division Federal Aid to Fish and Wildlife Restoration Project FW-3-R:128–183. Helena, Montana, USA.

Environmental Protection, Fish and Wildlife Service. 1993. Management plan for bighorn sheep in Alberta. Wildlife Management Planning Series Number 6. Edmonton, Alberta, Canada.

Geist, V. 1971. Mountain sheep, a study in behavior and evolution. University of Chicago Press, Chicago, Illinois, USA.

Hicks, L. L., and J. M. Elder. 1979. Human disturbance of Sierra Nevada bighorn sheep. Journal of Wildlife Management 43(4):909–915.

Horejsi, B. 1976. Some thoughts and observations on harassment of bighorn sheep. Pages 149–155 *in* T. Thorne, chairman. Proceedings of the Biennial Symposium of North American Bighorn Sheep Council. Jackson, Wyoming, USA.

Jones, L. C. 1994. Evaluation of lungworm, nutrition, and predation as factors limiting the recovery of the Stillwater bighorn sheep herd. Thesis, Montana State University, Bozeman, Montana, USA.

Keating, K. A. 1982. Population ecology of Rocky Mountain bighorn sheep in the upper Yellowstone River drainage, Montana/Wyoming. Thesis, Montana State University, Bozeman, Montana, USA.

Legg, K. L. 1996. Movements and habitat use of bighorn sheep along the upper Yellowstone River Valley, Montana. Thesis, Montana State University, Bozeman, Montana, USA.

Lemke, T. 1996. Annual report. Montana Fish, Wildlife and Parks, Helena, Montana, USA.

MacArthur, R. A., V. Geist, and R. H. Johnson. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. Journal of Wildlife Management 46:351–358.

Martin, S. 1985. Ecology of the Rock Creek bighorn sheep herd, Beartooth Mountains, Montana. Thesis, Montana State University, Bozeman, Montana, USA.

Meagher, M., W. J. Quinn, and L. Stackhouse. 1992. Chlamydial-caused infectious keratoconjunctivitis in bighorn sheep of Yellowstone National Park. Journal of Wildlife Disease 28(2):171–176.

Mills, H. B. 1937. A preliminary study of the bighorn of Yellowstone National Park. Journal of Mammalogy 18:205–212.

Oldemeyer, J. L., W. J. Barmore, and D. L. Gilbert. 1971. Winter ecology of bighorn sheep in Yellowstone National Park. Journal of Wildlife Management 35:257–269.

Reisenhoover, K. L., J. A. Bailey, and L. A. Wakelyn. 1988. "In my opinion," assessing the Rocky Mountain bighorn sheep management problem. Wildlife Society Bulletin 16(3):346–352.

Seton, E. T. 1913. Wild animals at home. Doubleday, Page & Company, Garden City, New York, USA.

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EFFECTS OF WINTER RECREATION ON BISON

POPULATION STATUS AND TREND

Bison (*Bison bison*) once roamed most of central North America and are native to the Greater Yellowstone Area (GYA). In the 1870s and 1880s, bison were nearly eliminated by market hunting; only a few small isolated populations remained. In Yellowstone National Park, poaching further reduced bison numbers, and, in 1902, 23 bison were counted in the Pelican Valley area of the park. To preserve the species, park managers imported 21 bison from captive herds in Montana and Texas and intensively managed the animals at the "Buffalo Ranch" in the Lamar Valley using livestock techniques. By the winter of 1926–27, the bison population had grown to more than 1,000 (Meagher 1973).

The ranching operation ended in the mid-1930s, when National Park Service (NPS) policy shifted from simple preservation to conservation of species in more natural conditions. The captive herd then intermingled with the remaining wild bison herd that survived in Pelican Valley. From the late 1930s through 1967, NPS managers utilized herd reductions to achieve range management goals. In 1967, when manipulative management of wildlife populations ceased, 397 bison were counted in the entire park. Bison numbers were then allowed to fluctuate in response to environmental factors. Since 1967, the bison population increased to a peak of 3,956 in the winter of 1994–95 and then declined to 3,398 in the winter of 1995–96.

In 1968, in response to livestock industry concerns about the disease brucellosis, the NPS proposed a program to control bison at the boundary of the park. Hazing, herding, baiting, physical barriers, and scare devices were used to discourage bison from leaving the park, generally with little success (Meagher 1989). Shooting bison was used as a last resort. From 1968–84, only a small number of bull bison were removed as they attempted to move beyond the park boundary. Beginning in 1985, the state of Montana used hunting to control bison moving from the park into Montana. In the severe winter of 1988–89, following summer drought and area fires, hunters in the state of Montana shot 569 bison as they left the northern portion of the park. Bison continued to leave the park each winter in varying numbers, and, in the extremely severe winter of 1996–97, Montana state officials and park rangers shot or captured and sent to slaughter 1,084 bison. This, added to estimates of 300–400 dying from such natural causes as extreme weather, winter kill, and starvation, brought the total bison population in Yellowstone down to an estimated 2,000 animals in spring 1997 (NPS 1998). After reproduction, the early winter population count was 2,105 bison for the winter of 1997–98.

LIFE HISTORY

Bison are highly social animals. Females and subadults wander together in large herds with bulls, singly or in small bands, on the periphery of the group. The rut occurs in late summer (July and early August), and calves are born in April and May. At a few hours of age, a calf can keep up with its mother (Meagher 1973).

A large bison bull may stand six feet at the shoulder and weigh 2,000 pounds. Female bison are similar in appearance to males, although they are smaller and have more slender horns that point forward. Bison have a heavily muscled neck that supports a massive head, which is swung back and forth in winter to move snow from forage.

HABITAT

Bison are grazers and consume large amounts of sedges and grasses. Bison do use forested areas. In winter bison are typically found in open meadows and thermally influenced areas. Yellowstone's bison winter in three fairly distinct areas with some overlap of animals between the wintering areas at various times during the year. These wintering areas are called the Northern (Lamar Valley), the Mary Mountain (Hayden Valley–Firehole River), and the Pelican Valley.

HUMAN ACTIVITIES

Winter recreational use can have several impacts on wildlife. These include harvest of animals (via trapping, hunting, poaching), habitat modification, pollution, and disturbance. These impacts can have a number of effects on wildlife species, including behavioral change or death. Behavioral change may consist of altered behavior, altered vigor, or altered productivity. The abundance, distribution, and demographics of populations can be affected, and this can result in changes in species composition and interactions among species (Knight and Cole 1995). Alteration of wildlife movements or displacement from normal wintering areas can result in higher energetic costs for winter-stressed wildlife, potentially decreasing production of young. Occasionally, direct mortality may occur as in the case of snowmobile–wildlife collisions.

There have been various studies related to winter recreation and its impact on wildlife as evidenced by recent literature reviews by Caslick and Caslick (1997) and Bennett (1995). However, there are few completed studies that specifically focus on the effects of winter recreation on bison.

POTENTIAL EFFECTS

MOVEMENTS

Bison establish a network of trails and travel routes in the winter as the snow depth and crust become severe. Bison often use rivers, streams, and marshes for travel as well as packed and groomed snowmobile trails (Aune 1981, Bjornlie and Garrott 1998). Groomed trails may be used extensively by bison; snow-packed roads used for winter recreation in Yellowstone National Park may be a major factor relating to the expanded distribution of bison in the park (Meagher 1993). According to Aune (1981), bison utilized groomed snowmobile trails regularly to travel from place to place. Bison were not observed using ski trails. Bjornlie and Garrott (1998) and Kurz (1998) also found that bison use the groomed roads as part of their network of trails; however, the majority of bison movements took place off of established roads and trails.

DISPLACEMENT

The most dramatic physiological defense response is observed when wildlife are provoked by humans on foot (Gabrielsen and Smith 1995, Cassirer 1990). The magnitude of the response depends on the distance, the movement pattern of the person(s), and the animal's access to cover. Animals will respond in a passive or active manner, depending on species and the particular situation.

In their initial response to human disturbance, bison usually "freeze" body movements, and there may be increased interaction among the bison group (Aune 1981). However, bison will also flee in response to disturbance; they usually flee by galloping or trotting away from the source of the disturbance (Aune 1981). The visual stimulus of a snowmobile or skier seems to initiate the flight response. Except for coyotes, Aune (1981) and Cassirer (1990) found that all wildlife species observed (mostly big game) reacted more quickly to an approaching skier than to a snowmobile, and the flight distance was generally greater from skiers. Bison were found to respond dramatically to skiers who were off established trails. All wildlife species studied, including bison, were wary of people on foot.

Most snowmobile–wildlife encounters occurred either early in the day (between 8 and 10 a.m.) or late in the day (between 5 and 6 p.m.). Most snowmobile–bison interaction occurred because of the bison's presence on groomed trails, and the number of interactions increased with snow depth (Aune 1981). Many bison flee when they encounter snowmobiles because they are "herded" down the trail by snowmobilers. Heavy human activity may temporarily displace wildlife from areas within 63 yards of the trail (Aune 1981). Heavy human activity sometimes occurs in areas that are winter range for big game such as bison. Snowmobile use is often more predictable and localized than skier activity and may cause less displacement of animals. Varied topography and good cover may reduce the frequency and intensity of displacement. Even a natural barrier, such as a river, may result in higher tolerance of snowmobile activity.

ENERGY EXPENDITURE

Winter recreational activity may significantly increase wildlife's expenditure of fat reserves. At the time of Aune's (1981) study, wildlife species in this area were dramatically increasing in population size, so the impact of winter recreational activity was apparently not influencing reproductive success. In some situations, wildlife may become habituated to human disturbance and the physiological responses decrease (Gabrielsen and Smith 1995). Wildlife, including bison, that are habituated gradually during the first two weeks of human disturbance (Aune 1981) may expend less energy when disturbed after that time.

Bison may use groomed snowmobile trails, packed trails, and plowed roads for travel through areas where surrounding snow is deep. However, bison may not use these trails if the packed routes are not within foraging areas or do not lead to them (Bjornlie and Garrott 1998). These types of routes facilitate bison movement by making movement more energy efficient. Bison may no longer be "snow-bound" in locations where they have had to spend the winter in the past. Increasing numbers of bison have adapted to snow-packed roads and are using them as a travel route to access forage sites (Meagher 1993). Despite the presence of snow-packed roads, bison continue to use natural corridors, such as riverbanks where snow depth is ameliorated (as along the Madison) or the riverbed itself, to reduce energy expenditures.

Bison in the GYA are particularly affected by human use of the following Potential Opportunity Areas (POA):

(4) Groomed motorized routes
(5) Motorized routes

Bison may also be an issue in POA (3) scenic driving routes. This depends on the effect that plowed roads have on bison movement, and how long this has been occurring. The road to Cooke City from Mammoth has been plowed since the 1940s. This road traverses the northern winter range. This area is considered big game winter range due to lesser snow depths in winter. Bison are known to travel on the plowed road, but it is unknown if the road facilitates travel to winter ranges that were not used by bison in the past or allows them to exit from areas where the snow becomes too deep.

There may be some concern in areas where cross-country skiing occurs, primarily POA (9) backcountry nonmotorized areas, because of the potential for stressing bison in the winter and causing energy loss.

CONTINUING RESEARCH

There are several bison research projects ongoing in the GYA, including:

1. Determining forage availability and habitat use patterns for bison in the Hayden Valley of Yellowstone National Park.
2. Seasonal movements and habitat selection by bison in Yellowstone National Park.
3. Development of aerial survey methodology for bison population estimation in Yellowstone National Park.
4. Spatial-dynamic modeling of bison carrying capacity in the greater Yellowstone Ecosystem—A synthesis of bison movements, populations dynamics, and interactions with vegetation.
5. Population characteristics of Yellowstone National Park bison.
6. Bison interactions with elk and predictive models of bison and elk carrying capacity, snow models, and population management scenarios in the Jackson Valley.
7. Bison use of groomed roads in the Hayden Valley and Gibbon Canyon to Golden Gate areas of Yellowstone National Park.
8. Statistical analysis and synthesis of 30 years of bison data.
9. The effects of groomed roads on the behavior and distribution of bison in Yellowstone National Park.
10. Assessing impacts of winter recreation on wildlife in Yellowstone National Park.

MANAGEMENT GUIDELINES

- Where possible, consider rerouting snowmobile trails so that they are located outside of critical bison winter ranges and bison concentration areas.
- Where major bison migration routes intersect groomed snowmobile trails or snowmobile-use routes, consider relocating snowmobile trails or user routes.
- If bison are traveling plowed highways that have berms, plow frequent “pull-outs” where bison can escape from vehicular traffic.
- Increase interpretive contacts with snowmobilers, skiers, and snowshoers to educate these winter recreational users about off-trail use and wildlife responses.
- Consider restricting human use in areas of critical wildlife winter range.
- Continue to study the influence of packed trails on bison movement and distribution. Determine if this influence is acceptable where it varies from historical versus critical winter use.

LITERATURE CITED

Aune, K. E. 1981. Impacts of winter recreationists on wildlife in a portion of Yellowstone National Park, Wyoming. Thesis, Montana State University, Bozeman, Montana, USA.

Bennett, L. E. 1995. A review of potential effects of winter recreation on wildlife in Grand Teton and Yellowstone National Parks: a bibliographic data base. University of Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, Wyoming, USA.

Bjornlie, D., and R. Garrott. 1998. The effects of winter groomed roads on the behavior and distribution of bison in Yellowstone National Park. 1998 Annual Progress Report, Montana State University, Bozeman, Montana, USA.

Caslick, J., and E. Caslick. 1997. New citations on winter recreation effects on wildlife. Unpublished report. National Park Service, Yellowstone National Park, Wyoming, USA.

Cassirer, E. F. 1990. Responses of elk to disturbance by cross-country skiers in northern Yellowstone National Park. Thesis, Montana State University, Bozeman, Montana, USA.

Gabrielson, G. W., and E. N. Smith. 1995. Physiological responses of wildlife to disturbance. Pages 95–107 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C., USA.

Knight, R. L., and D. N. Cole. 1995. Wildlife responses to recreationists. Pages 51–60 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C., USA.

Kurz, G. L. 1998. 1997–98 Hayden Valley bison monitoring progress report. National Park Service, Yellowstone National Park, Wyoming, USA.

Meagher, M. 1973. The bison of Yellowstone National Park. National Park Service Science Monograph 1:1–161.

———. 1989. Evaluation of boundary control for bison of Yellowstone National Park. Wildlife Society Bulletin 17(1):15–19.

———. 1993. Winter recreation-induced changes in bison numbers and distribution in Yellowstone National Park. Unpublished data. National Park Service, Yellowstone National Park, Wyoming, USA.

NPS (National Park Service). 1998. Draft Environmental Impact Statement for the Interagency Bison Management Plan for the State of Montana and Yellowstone National Park. Publication D-655. May 1998.

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EFFECTS OF WINTER RECREATION ON ELK

POPULATION STATUS AND TREND

By the early 1900s, elk (*Cervus elaphus*) populations throughout North America had been decimated by commercial exploitation, competition with domestic livestock, and habitat changes. Most of the estimated 50,000 remaining elk were concentrated in the Yellowstone National Park (YNP) and Jackson Hole areas (Seton 1927). Protection of wildlife in YNP through installation into Yellowstone of the U.S. Army in 1886 and passage of the Yellowstone Park Protection Act in 1894 helped to reduce illegal killing in the park, and by the early 1900s the park's elk population began to stabilize or increase in number (Houston 1982, Robbins et al. 1982). Conflicts with livestock operations, combined with a series of severe winters that resulted in heavy losses of elk, caused continued concern about the future of the elk population that wintered in the Jackson Hole area (Robbins et al. 1982). In response to these concerns, Congress in 1912 passed legislation authorizing creation of the National Elk Refuge (NER) in Jackson Hole. Since the early 1900s, when management efforts were directed primarily at preserving and enhancing elk populations in the Greater Yellowstone Area (GYA), the management of elk populations has undergone several phases. In YNP, predator control, winter feeding, and effective protection from poaching resulted in a stable or increasing elk population (Houston 1982), which, in turn, created concerns about habitat degradation. Beginning in the 1930s and continuing until 1969, an average of 327 elk per year were removed from the park (Houston 1982), mainly from the northern range, through trapping for translocation and shooting. In 1969, the park placed a moratorium on elk removals (Cole 1969). That period marked the beginning of a management philosophy that continues to the present, in which the park has attempted to allow natural processes, to the maximum extent possible, to regulate ungulate numbers within Yellowstone. After the NER was established in Jackson Hole, the elk population there began to stabilize, although the number of elk in the adjoining Grand Teton National Park (GTNP) continued to decline until mid-century (Smith and Robbins 1994). Managers have been concerned about the large numbers of elk wintering on a restricted area in the NER and the impacts that they may have on forage supply and habitat quality. Therefore, an elk hunt was established on the refuge and in a portion of the adjoining GTNP (Smith and Robbins 1994). The states of Montana, Idaho, and Wyoming manage elk herds in the GYA by monitoring herd numbers and often herd composition, setting population and habitat objectives, and conducting regulated hunts. All of the elk herds in the GYA are subject to hunting in at least a portion of their ranges. Some elk that summer in YNP, which is closed to hunting, may be hunted as they migrate south to winter range (Smith and Robbins 1994). Most of the elk herds in the GYA were either stable or increasing during the 1980s (USFWS 1994), although a few have experienced declines in recent years. Populations south of YNP have been at or above stated population objectives in recent years.

Currently, an estimated 50,000–60,000 elk inhabit the GYA, in 10–12 separate herds (USFWS 1994). The northern Yellowstone elk herd summers in the northern and eastern portions of YNP and surrounding mountains, and as far south as Yellowstone Lake (Houston 1982). This herd's winter range extends from the Lamar Valley in the northeastern corner of YNP, north and west to the Dome Mountain

Wildlife Management Area outside YNP (USFWS 1994). This herd numbered around 20,000 in the early 1990s (USFWS 1994), but counts in 1998 and 1999 indicate that the northern herd currently numbers around 12,000 animals (Montana Fish, Wildlife and Parks, unpublished data; National Park Service, unpublished data).

A migratory herd of approximately 3,000–4,000 elk summers in the northern mountains of YNP and moves into the southern portion of the Emigrant elk management unit north of YNP during winter (MFWP 1992). This herd, which has been increasing in recent years, joins a resident herd of approximately 800–1,000 elk that summers in the Absaroka Mountains north of Yellowstone and winters in the foothills east of the Yellowstone River, north of YNP (MFWP 1992).

Three herds inhabit the area to the west and northwest of YNP. The Madison–Firehole herd resides year-round in the Madison and Firehole river drainages within and adjacent to the western boundary of YNP. Numbering approximately 600–800 animals (USFWS 1994), this herd is generally non-migratory (Craighead et al. 1973). Geothermal sites and thermally influenced areas are critical to the overwinter survival of this herd, which winters in a harsh area where snow depths peak at 115–150 cm annually (Craighead et al. 1973, Pils 1998). The availability of thermally influenced areas with associated reduced snowdepths may provide an upper limit to the size of this herd (Craighead et al. 1973). Another population of elk summers in the Gallatin and Madison ranges within YNP and west of the YNP western boundary and winters east of the Madison River in the foothills of the Madison Range (USFWS 1994). This population is believed to be increasing and was estimated at nearly 7,000 in 1992 (MFWP 1992). The Gallatin herd summers primarily in the northwest corner of YNP and winters along the Gallatin River in the Gallatin Canyon area in Montana (USFWS 1994). This herd numbers approximately 1,200–1,400 animals (MFWP 1992). Wildlife managers are concerned about increasing development on this herd's winter range in addition to a lack of security cover (MFWP 1992). A sub-population of the Gallatin herd summers at high elevations along the Gallatin Mountain Range and in the northwest corner of YNP (USFWS 1994). This group winters in the mountainous areas west of the Yellowstone River and northwest of the YNP boundary. The total Gallatin area elk population was estimated at about 2,900 during the early 1980s (USFWS 1994), and had increased to approximately 3,600–3,800 by 1992 (MFWP 1992).

Three elk herds along the eastern boundary of YNP summer primarily in the park. The Clark's Fork herd winters along the Clark's Fork River northwest of Cody, Wyoming, and numbered approximately 3,600 animals in 1988 (USFWS 1994). The North Fork Shoshone herd winters along the North Fork Shoshone River drainage west of Cody, Wyoming. This herd was estimated at roughly 2,900 elk in the late 1980s (USFWS 1994). The Carter Mountain herd winters in the Carter Mountain area and along the South Fork Shoshone River southwest of Cody, Wyoming, and consists of approximately 3,100 elk (USFWS 1994).

To the south and southwest of YNP and GTNP are three elk herds that spend all or part of the year in the GYA. Elk from the Targhee herd south of YNP summer generally outside YNP and winter along the Idaho–Wyoming border south of YNP (Mack et al. 1990). Approximately 500 elk were counted in the Targhee herd in the late 1980s (USFWS 1994). The Jackson herd, which winters on the NER and in the Gros Ventre River Valley, summers in the mountains to the north and east, including areas in Yellowstone and Grand Teton national parks and portions of the Bridger–Teton National Forest (Mack et al. 1990, Smith and Robbins 1994). From 1978 to 1982, roughly 7,600 elk wintered on the NER annually (Smith and Robbins 1994). The entire Jackson elk herd was estimated at approximately 16,000 animals in 1988 (USFWS 1994). The Sand Creek elk herd in eastern Idaho, which numbered approximately 4,200–4,900 in the mid- to late 1980s, summers east of Highway 20 in or near YNP, and winters in the Sand Creek winter range southeast of Dubois, Idaho (Brown 1985).

LIFE HISTORY

Elk are gregarious animals, and for most of the year males and females remain grouped in separate herds. Females begin to restrict their range and gather in traditional rutting areas in August and September (Martinka 1969), where, by early October, they are joined by males (Nowak 1999). During October males compete for females and attempt to gain and hold a harem of females through displays involving high-pitched bugles, antler thrashing, urine spraying, and fighting (Murie 1951, Geist 1982, Nowak 1999). Males may incur serious injury during the rut, which is usually done by late October. Many elk populations in the western U.S. migrate to low elevation winter range (Nowak 1999), where they may aggregate in groups of up to several thousand animals (Boyd 1978). The gestation period is roughly 250–265 days (Clutton-Brock et al. 1982, Taber et al. 1982), after which usually a single calf is born, generally in late May or early June (Murie 1951, Peek 1982). Sex ratio at birth is usually 1:1 (Peek 1982). Females may separate themselves from the larger herd to give birth in isolated areas, where they remain with their calves for several weeks (Boyd 1978). Lactation may last 4–7 or more months (Nowak 1999). Females generally attain sexual maturity at about 2½ years of age, and then are capable of producing a calf annually (Nowak 1999). Males are capable of mating at the same age, but most do not successfully breed until much later because of competition from older bulls (Nowak 1999). In wild populations few elk live longer than 12–15 years, with males often living shorter lives than females because of injuries incurred during the rut and decreased ability to deal with poor forage condition during the winter when they are nutritionally stressed from the rut (Peek 1982, Nowak 1999). In heavily hunted populations, the ratio of adult bulls to adult cows may be quite low (Peek 1982). The major source of mortality in most elk populations, including those in the GYA, is hunter harvest and associated crippling loss and illegal kills (Peek 1982). Wolves, cougars, and occasionally coyotes and domestic dogs may prey on both adult and calf elk (Murie 1951, Hornocker 1970, Carbyn 1983, Murphy et al. 1992, Gese and Grothe 1995). Both black and grizzly bears may be an important predator on elk calves in some areas (Murie 1951, Singer et al. 1997). Other sources of mortality are drowning, miring in thermal mud, fighting during the rut, entanglement in fences, and starvation (winterkill) (Murie 1951). Vehicle collisions also contribute to elk mortality in most GYA herds.

HABITAT

Skovlin (1982) described the basic requirements of elk habitat. Habitat selection is determined by topography, weather, vegetational cover, and escape cover. Elevation is probably the most important topographic influence, determining seasonal availability of habitats. The most important influences of weather on elk habitat use are snow depth and condition, which limit elk movement and forage availability. Vegetative characteristics that are important determinants of elk habitat use include cover for both thermoregulation and hiding or escape, as well as forage availability. Elk are an ecotone species (Skovlin 1982). Studies have shown that although elk are primarily grazers, their use of an area was higher when shrubs were intermixed with forest stands or where forest stands contained more than one successional stage (Lonner 1976). Ecotones provide a greater variety of forage plants used by elk, and more plants occur at a variety of phenological stages because of differences in microclimates where habitat types are intermixed (Skovlin 1982).

With the exception of the population in the Madison River drainage in and adjacent to YNP (Craighead et al. 1973), elk in the GYA are migrators, tending to return to the same winter and summer ranges year after year (Peek 1982). Although they are not migratory, the Madison River elk do exhibit seasonal changes in habitat use (Craighead et al. 1973). Migrating elk often follow the same travel routes, which are determined by topographic features and natural travel lanes (Adams 1982). Although movement to winter range is dictated primarily by increasing snow depth and density at higher elevations (Adams 1982, Farnes et al. 1999), summer and winter ranges fulfill differing habitat needs for elk.

Summer Range

Because of their large body size, elk have a relatively slow fattening rate, so summer range and the pulse of vegetative productivity between spring and the rut in autumn is of great importance in their ability to build up reserves with which to survive the winter (Geist 1982). Adult female elk face serious energy demands during lactation (Nelson and Leege 1982), which occurs while they are on spring and summer range. Grass is the most important forage type for elk during the spring greenup months, usually making up more than 85 percent of their diet (Nelson and Leege 1982). Grasses, forbs, and browse are all used to varying degrees during the summer, depending on availability (Kowles 1975, Nelson and Leege 1982). Leaves of browse species may also be consumed (Peek 1982). In addition to providing high quality forage, spring and summer range must provide opportunities for escape from biting insects as well as shade for escape from heat stress. Interspersion of cover to open areas appears to be important in determining calving areas because of the need for hiding sites used by newborn calves (Peek 1982).

Winter Range

Snow depth and snow characteristics appear to be the driving factors in the timing and rate of elk migration to winter range (Lovaas 1970, Adams 1982). Characteristics important in elk use of winter range include areas of low snow cover to facilitate movement and access to forage, escape cover from predation, and security from harassment and associated energy expenditures. Areas used by elk in winter are often low elevation valleys where snow accumulations are low, but may also include windblown ridgetops and thermal areas and thermally influenced habitats where snow depths are generally low and some green vegetation may be found year-round (Craighead et al. 1973). Adult females, calves, and younger elk of both sexes generally winter in large groups in low elevation habitats (Adams 1982). Some females calve while on winter range, in which case hiding cover for calves is of critical importance as described above. Adult male elk generally seek widely dispersed small patches of habitat providing nutritious forage that will build up lost energy reserves and recover from injuries incurred during the rut (Geist 1982). Bulls are often found on the fringes of winter range occupied by cow/calf groups (Peek 1982) or at higher elevations and in areas of greater average snow depth. This separation of the sexes on the winter range may help to reduce competition for limited forage (Peek 1982). Elk diets on winter range are influenced strongly by forage availability, which is in turn affected by snow depth and density. In general, elk prefer to consume dried grasses during the winter, followed in preference by browse species and then conifers (Nelson and Leege 1982).

HUMAN ACTIVITIES

Elk face many obstacles in surviving the winter, some of which can be compounded by the impacts of human activities. Winter is an energetically difficult time, in which elk must carefully balance energy expenditures against energy intake in order to survive. Forage quality is lower in the winter than at any other time of year. In experimental feeding trials most elk lost weight on diets that mimicked winter diets (Nelson and Leege 1982). Winter habitat quality may play an important role in the reproductive success of females. The overwinter nutritional condition of elk has been correlated with reproductive success. Thorne et al. (1976) correlated high winter weight loss in pregnant females with prenatal calf loss, low calf birthweight, and low survival of newborns. Poor winter diet may also be associated with poor milk production (Taber et al. 1982). Adult males usually enter the winter in relatively poor condition and often injured as a result of rutting activity in the fall (Geist 1982). Quality of winter habitat alone may determine whether some males survive the winter, when forage quality is at its lowest and often is least accessible (Geist 1982). Up to approximately 87 percent of the daily forage consumed by an elk in winter is used for standard metabolic function, leaving less than 15 percent for growth, reproduction, temperature regulation, and activity (Nelson and Leege 1982). Because of the low quality of winter forage, elk often rely on reducing energy expenditures to increase their chances of surviving and successfully reproducing (Marchand 1996). Movement through snow is energetically costly for elk, becoming considerably more costly as snow depth exceeds knee height (Halfpenny and Ozanne 1989). Farnes et al. (1999) reported that when snow-water equivalent, a measure of snow density, reaches 6 inches, elk are generally unable to continue foraging in that area and must move to areas of lower snow depth or density. Elk are apparently unable to crater through snow deeper than approximately 40 cm in search of food, and at greater depths they may switch to foraging on browse (Marchand 1996), which is generally a poorer quality food than grasses. After elk have foraged in an area, the disturbed snow around craters often becomes very dense and precludes further foraging in that area, forcing elk to seek other areas or other sources of food (Farnes et al. 1999).

Elk rely on fairly restricted winter ranges in which food and cover may be limited or of marginal quality, and, consequently, any activity preventing them from using all or part of that range could have negative impacts on their ability to survive or to successfully reproduce. In many areas within the GYA historic winter range has been settled by humans and converted into developments or agricultural uses. Human settlement on historic winter range may decrease the quality or availability of winter range, through changes in habitat, increased harassment by humans, or competition with livestock (Skovlin 1982, Taber et al. 1982). The NER was created in response to the fact that much of the historic winter range in the Jackson Hole area had been converted to agricultural and other uses, depriving elk of critical habitat needed to survive the winter. Human settlement in the GYA may already have restricted some elk herds to smaller or less productive winter ranges, putting them at greater risk of negative impacts from other forms of disturbance or displacement. Cows with calves generally winter at lower elevations than do bulls (Adams 1982), but low elevation valleys and river corridors are also the areas most often used by humans for settlement, agriculture, and road-building (Glick et al. 1998). Elk in the Madison–Firehole elk herd are extremely restricted during the winter, surviving in small patches of thermally influenced habitat along the Madison and Firehole river corridors (Craighead et al. 1973, Aune 1981). The groomed road between West Yellowstone and Old Faithful, however, transects the core of this critical winter habitat (Aune 1981).

Some research has been conducted into the effects of disturbance on elk behavior and movements. Elk in some areas have apparently changed traditional travel routes in response to human settlement and to hunting pressure, particularly on winter range (Picton 1960, Kimball and Wolfe 1974, Smith and Robbins 1994). Logging activity in some areas has increased year-round access for recreationists into elk habitat, which in some areas has resulted in changes in elk distribution (Skovlin 1982). Declines in elk use of areas within 0.25–1.8 miles of roads have been reported, with distances varying according to the amount and kind of traffic, quality of the road, and density of cover adjacent to the road (Lyon and Ward 1982). Avoidance of roads results in habitat near roads becoming effectively unavailable to elk (Lyon 1983). Ward et al. (1976) and Hieb (1976) state that harassment can be of concern because elk will readily desert productive habitats when disturbance is excessive.

When elk groups crossing highways en route to winter range are interrupted by traffic, they have been observed spending a great deal of time searching for the rest of the group before continuing directional travel (Adams 1982). Logging roads with associated debris piled along the edges have proven to be barriers to elk movements in some areas (Lyon and Ward 1982). This is likely to also be true of snow berms piled along plowed roads during the winter. Elk flight distances in reaction to humans varies by season, habitat, conditioning, and type of human activity (Skovlin 1982). When elk are disturbed by hunters, they may travel long distances before stopping (Adams 1982), sometimes up to 8 miles before reaching security cover or protected areas (Altmann 1958). Solitary elk appear to have longer flight distances than do groups (Skovlin 1982). Elk experience an accelerated heart rate during the alert state immediately preceding flight caused by harassment, car horns, gunshots, and sonic booms (Ward and Cupal 1979), but elevated heart rate has rarely been linked to changes in reproduction or survival (Ferguson and Keith 1982). Repeated flight, however, particularly through deep snow, uses energy reserves that might otherwise be used to help elk survive the critical final weeks of winter (Skovlin 1982). Lyon and Ward (1982) reported that logging activity occurring on elk winter range results in less movement by elk than logging activity on summer range does, possibly due to the reduced vigor of elk during winter, the difficulty of movement in deep or crusted snow, and the lack of alternative areas to which to move. Aune (1981) also observed that in YNP, elk were less likely to flee from snowmobiles or skiers late in the winter than they were earlier in the season. He suggested that this was likely due in part to habituation by elk to snowmobile traffic, and in part to decreased vigor of elk later in the season combined with the increasing difficulty of flight through deep, crusted snow. Proximity of escape cover that breaks the line of sight between elk and the disturbance may reduce flight distances and consequently the amount of energy used in flight. Moving automobiles and trail bikes had little effect on elk resting in timber at distances of only 0.13 miles (Lyon and Ward 1982).

Findings from studies of elk behavior in response to specific human winter recreational activities are varied. Ferguson and Keith (1982) researched the influence of cross-country ski trail development and skiing on elk and moose distribution in Elk Island National Park in Alberta, Canada. They found no indication that overwinter distribution of elk was altered by cross-country skiing activity. However, it did appear that elk moved away from ski trails, particularly those that were heavily used, during the ski season. Anecdotal observations indicate that elk may be relatively sensitive to the sight and sound of snowmobiles, moving away when only a few machines are present (Bureau of Land Management, unpublished data in Bury 1978). Anderson and Scherzinger (1975) reported that when recreational snowmobile activity increased in the Bridge Creek Game Management Area in northeastern Oregon, winter elk counts decreased by 50 percent. After the area was closed to snowmobiling, the population returned to its previous numbers. Aune (1981) found that heavy snowmobile traffic in YNP occasionally inhibited free movement of wildlife, temporarily displacing them from certain areas. The most significant impact on wildlife distribution appeared to be within 60 m of groomed snowmobile trails. Aune (1981) also reported that snowmobile activity in YNP resulted in average elk flight distances of 33.8 m, compared to average flight distances of 53.5 m in response to skiers. In another study, elk began to move when skiers approached to within 15 m in an area heavily used by humans year-round, and within 400 m in an area where human activity is much lower (Cassirer et al. 1992). Elk in YNP fled more frequently and over greater distances from skiers off established trails than from skiers on established trails (Aune 1981). During winter in Rocky Mountain National Park, elk were relatively undisturbed by visitor activities occurring on roads, but they exhibited longer flight distances from an approaching person than from an approaching vehicle (Shultz and Bailey 1978). Ward (1973) reported that elk are easily conditioned to repeated patterns of human activity, but tend to be disturbed by deviations from normal patterns. In YNP, Aune (1981) found that wildlife species, including elk, were more likely to be displaced by or exhibit flight responses to snowmobile traffic during the pre-season when traffic was limited to occasional administrative travel than they were to the heavier traffic occurring during the recreational season. This may have resulted from habituation by elk to the presence of snowmobile traffic and to establishment of a more constant traffic pattern during the recreational season. This change in response may also have resulted from decreasing physical condition of elk later in the winter, and increasing snow depth and crusting that inhibited flight. Elk also demonstrated a shift to a more crepuscular activity pattern when recreational snowmobile activity increased (Aune 1981).

It has been suggested that the presence of groomed ski and snowmobile trails may provide a means for energy efficient travel for elk and other wildlife during winter. Ferguson and Keith (1982) found no indication that elk used groomed ski trails as preferred travel routes in Elk Island National Park, Alberta. Elk in the Madison–Firehole and Gibbon River corridors of YNP used groomed snowmobile trails increasingly as snow became deeper and more crusted and as animal condition declined through the winter (Aune 1981). Trails created by only one or two passes of a snowmobile and ungroomed ski trails, however, were not compacted sufficiently to support the weight of an elk and consequently were not used. Elk suffer greater chances of mortality from vehicle collisions when using roads and trails, particularly if they become trapped by plowed snow berms or other obstacles along road and trailsides.

POTENTIAL EFFECTS

Winter recreational activity can result in a variety of impacts on elk, depending on the nature and duration of the activity and the condition of the affected animals. Elk may readily habituate to predictable activity, so that recreational activities taking place on well-established routes and over a predictable time interval may have little effect on them after they become accustomed to the activity. Elk may learn to avoid areas of continual noise or disturbance, however, effectively removing a portion of otherwise available habitat from their use. This avoidance can have negative impacts on elk by reducing the amount or type of forage available and thereby adding to nutritional stress. Human activity occurring in low-snow areas may impact elk primarily because those areas are likely to be favored by elk late in winter when they are in poor condition. Antler hunting, for example, is an extremely popular activity during the late winter in many portions of elk habitat in the GYA, particularly on the northern range. This activity places humans generally on foot or horseback in low-snow winter range areas where bulls may be concentrated late in winter. The generally unpredictable, off-trail nature of this activity has the potential to create significant disturbance and stress to bull elk at a time when their energy reserves are at their lowest.

Conversely, elk may learn to use groomed roads or trails, and plowed roads as energy-efficient travel routes during the winter. It is not known whether the energy savings of using plowed and groomed roads and trails is greater or less than the costs of disturbance encountered while using such travel routes. Plowed roads may represent barriers to movement by elk if there are high snow berms on either side of the road, and may contribute to vehicle-caused mortality of elk using roads or trails. Roads may also provide energy efficient means of travel for predators in winter, increasing their ability to access prey and thereby increasing vulnerability of prey species such as elk.

Activities occurring in unexpected places or at unexpected times, such as skiing on lightly used trails or off-trail skiing, off-trail snowmobile use, or opening of previously closed areas can cause elk to flee, thereby using valuable energy reserves. Flight may be particularly costly for elk if snow is deep or crusted, or if elk are already in nutritionally stressed condition. Activity that occurs repeatedly but unpredictably may result in cumulative energy use over the course of the winter that might compromise an elk’s ability to survive or reproduce. Repeated disturbance that does not result in flight may create stress in the form of increased heart rate and hormonal and other physiological changes, but any effects that these changes may have on overall survival and reproduction have not been well researched. The effects of disturbance by humans may be lessened if adequate hiding cover is available nearby. Disturbances that occur late in winter, when elk are in their poorest physical condition and the forage supply may be depleted, are likely to have a more negative impact than those occurring earlier in winter. Inability of elk to move through late-winter deep and crusted snow may compound the stress associated with disturbance at that time.

Elk in the GYA are likely to be affected by human use of the following Potential Opportunity Areas:

(1) Destination areas. If such areas are newly created within elk winter range, they have the potential to displace elk from needed habitat. Elk may become accustomed to activity at destination areas if that activity is predictable. Irregular human activity at such areas may prompt flight response by elk in the vicinity.

(2) Primary transportation routes and (3) scenic driving routes. Transportation routes are often located in low-elevation areas and along river corridors, areas also often used by elk for travel and winter range. Habitat may become unavailable to elk through construction of transportation routes and through avoidance by elk of transportation corridors, particularly those that are heavily used. Routes with heavy traffic use or physical barriers along roadsides may interfere with elk travel and migration patterns. Vehicle collisions may result in mortality of individual elk.

(4) Groomed motorized routes and (5) motorized routes. Groomed routes are likely to have impacts similar to those of primary transportation routes and scenic routes, depending on the level of human use. Groomed routes may provide an energy efficient travel route for elk, but may also do the same for predators of elk.

(6) Backcountry motorized areas. Human activity in backcountry areas is likely to be less predictable than in other motorized recreation areas and, therefore, has more potential to create flight response in individual elk or groups of elk. Motorized use of these areas is likely to occur over a less-confined area than transportation routes, potentially increasing the area of disturbance or displacement of elk. This type of recreation usually occurs in higher elevation, deep-snow areas and so may impact only scattered groups of adult males.

(7) Groomed nonmotorized routes and (8) nonmotorized routes. If use of these areas is predictable and confined to a defined area, elk may become habituated to the human activity occurring there. Nevertheless, elk could be displaced from areas immediately adjacent to groomed routes, and individuals or groups of elk may be prompted to flee from humans using such routes. Elk are more likely to flee from activity occurring on ungroomed routes because of the unpredictable nature of that use. Use of nonmotorized routes is, however, likely to be less frequent than that of groomed routes.

(9) Backcountry nonmotorized areas. Although use of these areas is unpredictable and, therefore, likely to produce flight response in elk, this type of use is likely to be infrequent enough to prevent recurrent stress of elk wintering in these areas. Backcountry skiing areas are also likely to be in higher elevation, deep-snow areas where fewer elk groups winter.

(10) Downhill sliding (nonmotorized). These areas are likely to be limited in number and size and are likely to be located adjacent to roads or groomed motorized trails. Disturbance associated with these areas is likely to be only slightly increased over disturbance from the transportation route used to access them.

(12) Low-snow recreation areas. One of the primary characteristics in elk choice of wintering areas is low snow depth. Therefore, human activities in these areas have potential to displace elk from important winter range. Elk may completely avoid such areas if human use is heavy or unpredictable, thus depriving them of access to forage and easy travel routes. Although habituation is possible to activities occurring in a predictable fashion, disturbance by humans can cause repeated flight response, causing stress and energy consumption by elk. Cows and calves generally winter in low-snow areas, and those affected by continued disturbance or displacement may suffer decreased reproductive success or ability to survive harsh winters.

Management Guidelines

- Avoid construction of new facilities in elk winter range and place any necessary construction in or adjacent to already disturbed areas. Elk winter range in many parts of the GYA is being converted to developments and other uses, so additional removal of winter habitat should be avoided.
- Regulate human activities so that they occur in defined areas in as predictable a fashion as possible. Elk may become habituated to regular human activity, decreasing flight response and consequent energy expenditure. Generally, moving traffic creates less disturbance than destination points or areas where humans are out of vehicles.
- Structure areas of human use and development so that there are buffer zones between humans and elk-use areas. Create or maintain sight barriers (brushy or forested areas) adjacent to human-use areas, thereby reducing the distance elk must flee to find hiding cover.
- Avoid placing transportation and motorized routes in low-elevation, low-snow, riparian, and open habitats favored by elk. Where this is necessary, attempt to occasionally move the route away from those areas and through denser timber or areas with adequate hiding cover. Avoid creating roadside barriers that may prevent elk from crossing roads or trails or that may trap animals along the route.
- Limit human activity in low-snow winter range areas. Where it occurs, keep activity concentrated in established areas.
- Consider limiting or removing livestock from low-snow wintering areas where they compete with elk, in order to mitigate for habitat losses occurring through developments on elk winter range in other areas.
- Carefully research elk use of particular areas before creating new human activity zones. Avoid creating new developments or disturbances in areas where elk have no alternative winter range to use or where impacts cannot be adequately mitigated.

Literature Cited

Adams, A. A. 1982. Migration. Pages 301–322 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Altmann, M. 1958. The flight distance in free-ranging big game. Journal of Wildlife Management 22:207–209.

Anderson, E. W., and R. J. Scherzinger. 1975. Improving quality of winter forage for elk by cattle grazing. Journal of Range Management 28:120–125.

Aune, K. E. 1981. Impacts of winter recreationists on wildlife in a portion of Yellowstone National Park, Wyoming. Thesis, Montana State University, Bozeman, Montana, USA.

Boyd, R. J. 1978. American elk. Pages 11–29 *in* J. L. Schmidt and D. L. Gilbert, editors. Big Game of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Brown, C. G. 1985. The Sand Creek elk, northeast Idaho: population status, movements and distribution. Job Completion Report, Project Number W-160-R. Idaho Department of Fish and Game, Boise, Idaho, USA.

Bury, R. L. 1978. Impacts of snowmobiles on wildlife. Transactions of the North American Wildlife Conference 43:149–156.

Carbyn, L. N. 1983. Wolf predation on elk in Riding Mountain National Park, Manitoba. Journal of Wildlife Management 47:963–976.

Cassirer, E. F., D. J. Freddy, and E. D. Ables. 1992. Elk responses to disturbance by cross-country skiers in Yellowstone National Park, Wyoming. Wildlife Society Bulletin 20:375–381.

Clutton-Brock, T. H., F. E. Guinness, and S. Albon. 1982. Red deer: behavior and ecology of two sexes. University of Chicago Press, Chicago, Illinois, USA.

Cole, G. F. 1969. The elk of Grand Teton and southern Yellowstone National Parks. National Park Service Resource Report GRTE-N-1.

Craighead, J. J., F. C. Craighead, Jr., R. L. Ruff, and B. W. O'Gara. 1973. Home ranges and activity patterns of non-migratory elk of the Madison drainage herd as determined by biotelemetry. Wildlife Monograph Number 33. The Wildlife Society, Washington, D.C., USA.

Farnes, P., C. Heydon, and K. Hansen. 1999. Snowpack distribution in Grand Teton National Park and the Snake River drainage above Jackson, Wyoming. Report to the National Park Service, Grand Teton National Park, Wyoming. Montana State University, Bozeman, Montana, USA.

Ferguson, M. A. D., and L. B. Keith. 1982. Influence of Nordic skiing on distribution of moose and elk in Elk Island National Park, Alberta. Canadian Field Naturalist 96:69–78.

Geist, V. 1982. Adaptive behavioral strategies. Pages 219–278 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Gese, E. M., and S. Grothe. 1995. Analysis of coyote predation on deer and elk during winter in Yellowstone National Park, Wyoming. American Midland Naturalist 133:36–43.

Glick, D., D. Cowan, R. Bonnie, D. Wilcove, C. Williams, D. Dellasala, and S. Primm. 1998. Incentives for conserving open lands in greater Yellowstone. Greater Yellowstone Coalition, Bozeman, Montana, USA.

Halfpenny, J. P, and R. D. Ozanne. 1989. Winter: an ecological handbook. Johnson, Boulder, Colorado, USA.

Hieb, S. R., editor. 1976. Proceedings of elk/logging roads symposium. University of Idaho, Moscow, Idaho, USA.

Hornocker, M. G. 1970. An analysis of mountain lion predation upon mule deer and elk in the Idaho Primitive Area. Wildlife Monograph Number 21. The Wildlife Society, Washington, D.C., USA.

Houston, D. B. 1982. The Northern Yellowstone Elk: ecology and management. Macmillan, New York, New York, USA.

Kimball, J. F., and M. L. Wolfe. 1974. Population analysis of a northern Utah elk herd. Journal of Wildlife Management 38:161–174.

Knowles, C. J. 1975. Range relationships of mule deer, elk, and cattle in a rest-rotation grazing system during summer and fall. Montana Department of Fish and Game, Federal Aid Project W-120-R, Job BG-10.01. Helena, Montana, USA.

Lonner, T. N. 1976. Elk use-habitat type relationships on summer and fall range in Long Tom Creek, southwestern Montana. Pages 101–109 *in* S. R. Hieb, editor. Proceedings of the elk/logging roads symposium. University of Idaho, Moscow, Idaho, USA.

Lovaas, A. L. 1970. People and the Gallatin elk herd. Montana Department of Fish and Game, Helena, Montana, USA.

Lyon, L. J. 1983. Road density models describing habitat effectiveness for elk. Journal of Forestry.

———, and A. L. Ward. 1982. Elk and land management. Pages 443–478 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Mack, J. A., W. G. Brewster, and M. E. Messsaros. 1990. The ungulate prey base for wolves in Yellowstone National Park II: elk, mule deer, white-tailed deer, moose, bighorn sheep and mountain goats in the areas adjacent to the park. Pages 2–41 *in* Wolves for Yellowstone? A report to the U.S. Congress, Volume II, research and analysis. National Park Service, Yellowstone National Park, Wyoming, USA.

Marchand, P. J. 1996. Life in the cold: an introduction to winter ecology. Third edition. University Press of New England, Hanover, New Hampshire, USA.

Martinka, C. J. 1969. Population ecology of summer resident elk in Jackson Hole, Wyoming. Journal of Wildlife Management 33:465–481.

MFWP (Montana Fish, Wildlife and Parks). 1992. Statewide elk management plan for Montana. Helena, Montana, USA.

Murie, O. J. 1951. The elk of North America. Stackpole Books, Harrisburg, Pennsylvania, USA.

Murphy, K. M., G. S. Felzien, and S. E. Relyea. 1992. The ecology of the mountain lion in the northern Yellowstone ecosystem. Hornocker Wildlife Institute Progress Report Number 5. Moscow, Idaho, USA.

Nelson, J. R., and T. A. Leege. 1982. Nutritional requirements and food habits. Pages 323–368 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Nowak, R. M. 1999. Pages 1110–1113 *in* Volume II, Walker's Mammals of the World. Sixth edition. Johns Hopkins University Press, Baltimore, Maryland, USA.

Peek, J. M. 1982. Elk. Pages 851–861 *in* J. A. Chapman and G. A. Feldhammer, editors. Wild Mammals of North America: biology, management, economics. Johns Hopkins University Press, Baltimore, Maryland, USA.

Picton, H. D. 1960. Migration patterns of the Sun River elk herd, Montana. Journal of Range Management 24:279–290.

Pils, A. L. 1998. Sampling and analysis methods for snow-urine nutritional assays. Thesis, Montana State University, Bozeman, Montana, USA.

Robbins, R. R., D. E. Redfearn, and C. P. Stone. 1982. Refuges and elk management. Pages 479–508 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Seton, E. T. 1927. Lives of game animals. Doubleday, Page and Company, Garden City, New York, USA.

Shultz, R. D., and J. A. Bailey. 1978. Responses of national park elk to human activity. Journal of Wildlife Management 42:91–100.

Singer, F. J., A. Harting, K. K. Symonds, and M. B. Coughenour. 1997. Density dependence, compensation, and environmental effects on elk calf mortality in Yellowstone National Park. Journal of Wildlife Management 61:12–25.

Skovlin, J. M. 1982. Habitat requirements and evaluations. Pages 369–414 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Smith, B. L., and R. L. Robbins. 1994. Migrations and management of the Jackson elk herd. National Biological Survey. Resource Publication Number 199. Washington, D.C., USA.

Taber, R. D., K. Raedeke, and D. A. McCaughran. 1982. Population characteristics. Pages 279–300 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Thorne, E. T., R. E. Dean, and W. G. Hepworth. 1976. Nutrition during gestation in relation to successful reproduction in elk. Journal of Wildlife Management 40:330–335.

USFWS (U. S. Fish and Wildlife Service). 1994. The reintroduction of gray wolves to Yellowstone National Park and central Idaho. Final Environmental Impact Statement. Washington, D.C., USA.

Ward, A. L. 1973. Elk behavior in relation to multiple uses on the Medicine Bow National Forest. Proceedings of Western Association State Game and Fish Commission 53:125–141.

———, and J. J. Cupal. 1979. Telemetered heart rate of three elk as affected by activity and human disturbance. Pages 47–56 *in* proceedings of the symposium on dispersed recreation and natural resource management. Utah State University, Logan, Utah, USA.

———, ———, A. L. Lea, G. A. Goodwin, and H. D. Morris. 1976. Effects of highway construction and use on big game populations. Federal Highway Administration Report Number FHWA-RD-76. Washington, D.C., USA.

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EFFECTS OF WINTER RECREATION ON GRAY WOLVES

POPULATION STATUS AND TREND

Gray wolves *(Canis lupus)* were once distributed throughout North America and were native to the Yellowstone area (Bangs and Fritts 1996). In the conterminous United States, they were extirpated to 3 percent of their historical range (Fuller et al. 1992). In the Greater Yellowstone Area (GYA), wolves were eliminated by the mid-1930s as a result of systematic predator control (Weaver 1978).

Following the approval of the 1994 environmental impact statement on the reintroduction of gray wolves into the Yellowstone and central Idaho ecosystems, wolves were reintroduced to these areas in 1995 and 1996 (USFWS 1994). Although wolves are classified as "endangered" in Montana, Idaho, and Wyoming under the Endangered Species Act of 1973 (USC 1531, 1982 amend.), they were reclassified as "experimental/non-essential populations" in the Yellowstone and central Idaho ecosystems before they were reintroduced to allow more flexibility in managing the species. This designation allows government agencies more options for relocating or removing individual wolves preying on livestock (USFWS 1994).

In 1995, 14 wolves were reintroduced into Yellowstone National Park using three "soft release" pen sites; 17 additional wolves were reintroduced to the park in 1996, and four pen sites were used (Phillips and Smith 1997). In January 1999, there were approximately 116 wolves in at least seven packs within the GYA (Bangs et al. In Press).

LIFE HISTORY

Wolves are highly social and hierarchical, and they live in family groups called packs. Packs consist of the dominant or "alpha" breeding pair, their recent litter of pups, and other adult and subadult individuals (Mech 1970, Tilt et al. 1987). During early spring (mid-March to early April), wolf packs excavate a den and rear a litter of pups. Average estimated birth date for wolf pups in the Yellowstone area in 1995 and 1996 was April 24 (Phillips and Smith 1997); pups are nursed six to eight weeks. At one to two years of age, a young wolf leaves the pack and tries to form its own pack.

Wolves depend upon ungulates for food. In the Yellowstone area, the primary prey for wolves is elk (87%); other prey includes moose, deer, antelope, and bison (Phillips and Smith 1997). Wolves prey on ungulates throughout the year (Tilt et al. 1987), and use ungulate carcasses (elk and bison) during early spring prior to denning. The peak period of availability of carcasses occurs about mid-April (Green et al. 1997; D. Smith, Yellowstone National Park, personal communication).

HABITAT

Wolves are not habitat specific and use much of the landscape within their pack's established territory (Mladenoff et al. 1995), however, snow depth and condition can influence wolf movements in the winter (Mech 1970, Paquet et al. In Press). Winter foraging occurs primarily on ungulate winter range. The ungulate winter range is also the key spring habitat for wolves as most winter-killed carcasses are found here.

HUMAN ACTIVITIES

Winter recreation has the potential to affect gray wolf movements and habitat use during the period of winter foraging and early spring denning. In the GYA, winter foraging typically occurs on the following ungulate winter ranges: the Yellowstone northern range (Mack and Singer 1992), the North Fork of the Shoshone River, the Jackson Hole basin, the Clarks Fork River (Boyce and Galliard 1992), and the areas that are geothermally influenced within Yellowstone National Park (Green et al. 1997).

Some information exists on specific effects of winter recreation on gray wolves. Most information, however, is available from data on the effects of other human activities. Paquet et al. (In Press) found that winter movements of wolves in Canadian parks were influenced by human activities. Winter activities that compact snow cover, such as snowmobiling, cross-country skiing, and maintenance of winter roads, provided feasible travel routes for wolves into areas that were usually inaccessible because of deep snow (more than 15.5–19.5 inches). The consequences of this are that there may be modifications to wolf/prey interactions and habitat use as well as differences in landscape movements between groups of prey (Paquet et al. In Press).

Studies of snowmobile use and wolf movements in Voyagers National Park (NPS 1996) have shown that wolves tended to avoid areas of snowmobile activity in restricted-use areas. The studies also showed that repeated avoidance or displacement could result in permanent displacement, an impact to an animal's winter energy budget, and/or a conditioning of the animal to avoid certain areas. While the study did not prove that winter recreational use harmed wolves, it suggested that the National Park Service should close important wolf foraging areas to winter use until a better understanding of wolf–snowmobile interactions could be determined.

Other studies have documented similar responses by wolves in the avoidance of roads. In Kenai National Wildlife Refuge, radio-collared gray wolves avoided year-round access roads open to public use and were attracted to roads that were closed or were managed for limited human use. Wolves used low-use roads as travel corridors (Thurber et al. 1994). Wolf avoidance of settled areas and public roads in this study area was more a result of behavioral avoidance rather than direct mortality of animals. In Jasper National Park, wolves avoided traveled roads and were negatively affected by disturbance at den sites (Carbyn 1974). In Yellowstone National Park, wolves use areas near groomed snowmobile roads because there are ungulates wintering in the vicinity. On one occasion in 1997, wolves initially used an elk kill along a groomed snowmobile road and then left it when humans were present (D. Smith, Yellowstone National Park, personal communication).

Developments in Canada were shown to negatively affect wolves in Banff, Yoho, and Kootenay national parks. In Banff National Park, the town of Banff partially blocks natural wolf movement, denying access to prime habitat east of town (Purves et al. 1992).

POTENTIAL EFFECTS

Winter recreation has the potential to affect gray wolves during winter foraging and denning periods. Potential wolf/human conflicts could occur in winter foraging habitats, along snowmobile and ski trails, or near developments. The literature shows that wolves both used and avoided roads and trails designated for winter use. Although wolves use snowmobile trails for travel and foraging, they avoid roads, trails, and facilities if humans are present. The ecological significance of altering natural movement and foraging patterns is not fully known. Human activity during late winter/early spring could also displace wolves during the sensitive denning period.

Gray wolves in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(1) Destination areas. Wolves may avoid habitats near winter developments when they occur on or near important ungulate winter ranges and when the developments remain open during spring denning periods (early to mid-April). This is especially critical when developments occur in or near high-quality winter and spring habitats that may include geothermally influenced winter range, low-elevation winter range, and other areas where winter-killed carcasses are found.

(2) Primary transportation routes and (3) scenic driving routes. Primary roads may affect wolf populations by fragmenting pack movement and causing direct mortalities. Five wolves were killed by vehicles in Yellowstone National Park between 1995 and 1997 (Gunther et al. 1998).

(4) Groomed motorized routes. Conflicts could occur when routes groomed for snowmobiles bisect habitats used by wolves in the winter, affecting wolf movements and foraging patterns. Moreover, grooming of roads and trails may affect ungulate movements (Meagher 1993), and this may influence wolf movements as well (Paquet et al. In Press). Areas of particular concern are ungulate concentration sites where winter-killed carcasses are available. These include both geothermally influenced and low-elevation winter ranges.

(6) Backcountry motorized areas. Wolf activity could be affected in ungroomed areas used by snowmobiles. Although areas of ungroomed snowmobile use typically occur at high elevations where wolves do not occupy winter habitats, there is potential for conflicts between wolves and recreationists if winter snowmobiling occurs on low-elevation or geothermally influenced ungulate winter range. Impacts would also occur if wolves were deliberately chased by recreationists on snowmobiles.

MANAGEMENT GUIDELINES

- New winter recreational developments should not be built near ungulate winter ranges or where they would impede wolf movements between high-quality habitats. Moreover, existing destination areas should be closed by April 1 to prevent the displacement of wolves during critical denning periods.
- By definition, year-round routes will remain open whether winter recreation occurs or not. Wildlife managers should immediately remove road-killed animals from roadsides to prevent foraging wolves from being hit by vehicles.
- New groomed motorized routes should be located in areas that are not classified as ungulate winter range or important wolf habitat. Grooming and use of snowmobile roads and trails should end between March 15 and April 1, allowing wolves to use spring denning sites without harassment. Human use of geothermally influenced winter ranges in the Firehole, Gibbon, and Norris areas of Yellowstone National Park should be managed during winter in a manner that allows wolves to forage; human use may cause displacement from these high quality habitats.

- Dispersed motorized use should not occur on or near ungulate winter range or on spring range after wolf denning begins, usually between March 15 and April 1.

LITERATURE CITED

Bangs, E. B., and S. H. Fritts. 1996. Reintroducing the gray wolf to central Idaho and Yellowstone National Park. Wildlife Society Bulletin 24(3):402–413.

———, ———, J. Fontaine, D. Smith, K. Murphy, C. Mack, and C. Niemeyer. In Press. Status in wolf restoration in Montana, Idaho and Wyoming. Wildlife Society Bulletin.

Boyce, M. S., and J. M. Galliard. 1992. Wolves of Yellowstone, Jackson Hole, and the North Fork of the Shoshone River: simulating ungulating consequences of wolf recovery. Pages 43–70 *in* Wolves for Yellowstone? A report to the United States Congress, Volume 4, research and analysis. National Park Service, Yellowstone National Park, Wyoming, USA.

Carbyn, L. N. 1974. Wolf population fluctuations in Jasper National Park, Alberta, Canada. Biological Conservation 6(2):94–101.

Fuller, T. K., W. E. Berg, G. L. Raddle, M. S. Lenarx, and G. B. Joselyn. 1992. A history and current estimate of wolf distribution and numbers in Minnesota. Wildlife Society Bulletin 20:42–55.

Green, G. I., D. J. Mattson, and J. M. Peek. 1997. Spring feeding on ungulate carcasses by grizzly bears in Yellowstone National Park. Journal of Wildlife Management 61(4):1040–1055.

Gunther, K. A., M. J. Biel, and H. L. Robison. 1998. Factors influencing the frequency of roadkilled wildlife in Yellowstone National Park. Pages 32–42 *in* G. L. Evink, P. Garrett, D. Zeigler, and J. Berry, editors. Proceedings of the International Conference on Wildlife Ecology and Transportation. Florida Department of Transportation, FL-ER-69–98. Fort Meyers, Florida, USA.

Mack, J. A., and F. J. Singer. 1992. Predicted effects of wolf predation on northern range elk, mule deer, and moose using POP-II models. Pages 3–42 *in* Wolves for Yellowstone? A report to the United States Congress, Volume 4, research and analysis. National Park Service, Yellowstone National Park, Wyoming, USA.

Meagher, M. 1993. Winter recreation-induced changes in bison numbers and distribution in Yellowstone National Park. Unpublished data. National Park Service, Yellowstone National Park, Wyoming, USA.

Mech, L. D. 1970. The wolf: the ecology and behavior of an endangered species. Natural History Press. Garden City, New York, USA.

Mladenoff, D. J., T. A. Sickley, R. G. Haight, and A. P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in the northern Great Lakes region. Conservation Biology 9(2):279–294.

NPS (National Park Service). 1996. Restricted winter use report, Voyageurs National Park (1992–1996). Voyageurs National Park, International Falls, Minnesota, USA.

Paquet, P. C., D. Poll, S. Alexander, C. McTavish, and C. Callaghan. In Press. Influences of snow conditions on movements of wolves in Canadian mountain parks. Journal of Wildlife Management.

Phillips, M. K., and D. W. Smith. 1997. Yellowstone wolf project: biennial report 1995–1996. National Park Service, Yellowstone National Park, Wyoming, USA.

Purves, H. D., C. A. White, and P. C. Paquet. 1992. Wolf and grizzly bear habitat use and displacement by human use in Banff, Yoho, and Kootenay national parks: a preliminary analysis. Heritage Resources Conservation. Canadian Park Service, Banff, Alberta, Canada.

Thurber, J. M., R. O. Peterson, T. D. Drummer, and S. A. Thomasa. 1994. Gray wolf response to refuge boundaries and roads in Alaska. Wildlife Society Bulletin 22(1):61–68.

Tilt, W., R. Norris, and A. S. Eno. 1987. Wolf recovery in the northern Rocky Mountains. National Audubon Society and National Fish and Wildlife Foundation. Washington, D.C., USA.

USFWS (U.S. Fish and Wildlife Service). 1994. The reintroduction of gray wolves to Yellowstone National Park and central Idaho. Final Environmental Impact Statement. Helena, Montana, USA.

Weaver, J. 1978. The Wolves of Yellowstone. Natural Resources Report, No. 14. National Park Service, Washington, D.C., USA.

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EFFECTS OF WINTER RECREATION ON GRIZZLY BEARS

POPULATION STATUS AND TREND

Historically, grizzly bears *(Ursus arctos horribilis)* ranged throughout most of western North America. Today, only a fraction of historic population levels occupy a remnant of their former distribution range (USFWS 1993). Loss or degradation of habitat in conjunction with unregulated hunting and livestock depredation control are cited as the main factors contributing to their decline (USFWS 1993). Grizzly bear populations have persisted only where large areas of public land maintained in a natural state provide necessary habitat components. Limited and/or regulated human activity has proven to be a requirement for the maintenance of grizzly populations (Mattson 1990). Today, there are six recovery zones designated within the conterminous United States (USFWS 1993). One of these zones includes a portion of the Greater Yellowstone Area (GYA), where a self-perpetuating grizzly bear population exists.

Under the authority of the Endangered Species Act (ESA), the U.S. Fish and Wildlife Service listed the grizzly bear as a threatened species in 1975. Recovery goals for the Yellowstone grizzly have since been established (USFWS 1993). However, the bear's long-term future remains uncertain and controversial. Threats to its existence are numerous (Picton et al. 1985, Mattson and Reid 1991, Eberhardt et al. 1994, Eberhardt and Knight 1996). In addition, determining population size and the characteristics used as a basis for trend predictions have been problematic (Schullery 1992, Eberhardt et al. 1994, Eberhardt and Knight 1996).

The grizzly bear population declined in the early 1970s following the closure of open garbage dumps and subsequent human-caused mortality around the GYA. Since then, trend data indicate a modest population increase (Eberhardt and Knight 1996). While grizzly bear mortalities, including human-caused deaths, have varied widely in the GYA during the past decade, cub production has increased (Eberhardt et al. 1994, Eberhardt and Knight 1996). A turning point in the earlier trend came in the mid-1980s when government agencies committed substantial resources toward the goal of preventing adult female grizzly bear mortality and protecting important grizzly bear habitat (Eberhardt et al. 1994, Gunther 1996).

Human-caused mortality of grizzlies, especially females, continues to be of particular concern in the recovery of this species; direct human-caused mortality is the cause of virtually all grizzly bear population declines and extinctions (Mattson 1993). There are several factors that complicate efforts to deal with this issue. It is impossible to predict the number of bear mortalities that will occur in a given time frame, and the range of variation from year to year can be large. Although the grizzly population may be increasing, human use of the GYA is also increasing. This means the potential for bear–human conflicts and human-caused mortalities persist and will probably grow.

Numerous researchers have analyzed grizzly bear mortality data for the GYA (Povilitis 1987, Craighead et al. 1988, Knight et al. 1988, NPS 1988). Their findings indicate that most grizzly bear mortalities since 1974 involve humans and can be classified as either illegal shootings or management-control actions. Povilitis (1987) found that almost half of the mortality risk was associated with people carrying firearms on national forest lands. Within Yellowstone National Park, almost all grizzly bear mortalities were the result of management actions by the National Park Service against habituated, human-food-conditioned grizzlies (Gunther 1994).

Knight et al. (1988) reported that known and probable deaths of grizzly bears tend to be centered around specific areas in and around Yellowstone National Park. They described these as “population sinks” and identified them as the gateway communities surrounding Yellowstone National Park, major development areas within the park, sheep grazing allotments, and various other human concentration areas.

One of the major problems associated with human development in occupied bear habitat is the availability of attractants (garbage and human and pet food). Human garbage is cited as one of the major contributors to bear conflicts with humans (Herrero 1985). If food is obtained at one of these sites by a bear, the bear may periodically check the site for more food. The bears that are thus conditioned are often the target of management actions and usually become mortalities.

Bears are also killed by illegal shooting. These shootings may be categorized as self-defense, defense of property, hunters mistaking grizzlies for black bears, and poaching. An increase in people in areas where there are bears increases the likelihood of mortalities by shooting. There are other issues to consider in the long-term status of the Yellowstone grizzly bear. The population may reach carrying capacity, causing a decrease in subadult survival (Eberhardt and Knight 1996). Available food may be reduced by climatic change (Picton et al. 1985, Mattson and Reid 1991), loss of whitebark pine from blister rust infection (Kendall and Arno 1990, Mattson and Reid 1991), and a decrease in Yellowstone cutthroat trout as a result of whirling disease and competition with lake trout (Varley and Schullery 1995).

LIFE HISTORY

Much is known about the life history of the Yellowstone grizzly bear (McNamee 1984). However, only those details that relate to the topic of winter recreation use will be mentioned here. Cubs are born in the den from late January to early February. They are helpless and rely on the mother for warmth and nourishment. The average litter size is about two (Schullery 1992). This is a time when both mother and offspring are especially vulnerable (Reynolds and Hetchel 1980).

HABITAT

DENNING

In a five-year study of Yellowstone grizzly bears in the late 1970s, November 9 was found to be the mean entrance date for 70 bears tracked to their dens. The earliest entrance date recorded was September 28 for a pregnant female and the latest was December 21. Pregnant females entered dens earliest, but differences in the mean denning dates of sex and age groups other than pregnant females were not significant. Bears frequented the immediate area of den sites from 8 to 22 days before entering (Judd et al. 1986).

Male grizzlies were usually the first to leave their dens, emerging between mid-February and late March. The other population segments generally emerged in the following order: single females and those with yearlings and two-year-olds followed by females with new cubs. The last group emerged between early and mid-April (Judd et al. 1986).

Judd et al. (1986) concluded that bears did not seek den sites in open areas or show strong preference for a specific type of canopy coverage; however, sites with whitebark pine and subalpine fir appeared to be preferred for dens. Both tree species are found at higher elevations. Elevation of dens ranged from 6,500 to

10,000 feet; and the average elevation was 8,100 feet, with an apparent clumping in the range of 8,000 to 9,000 feet.

Dens were found on all aspects, but there was an apparent preference for north exposures. Most dens were found in the 30 to 60 degree slope range. Some dens were reused, but others collapsed after a season of use (Judd et al. 1986).

Judd et al. (1986) concluded that availability of denning sites did not appear to be a critical element of grizzly bear habitat in the Yellowstone area since grizzly bears appear to be able to use sites with a wide range of environmental characteristics. In addition, given the amount of protected habitat in Yellowstone National Park and the surrounding national forest wilderness areas as well as the large size of a grizzly bear's home range, they did not think den sites would become scarce in the foreseeable future.

Denning studies in Canada, Alaska, and the Northern Continental Divide Ecosystem (IGBC 1987) indicate that while there are differences in entry and emergence dates, there is commonality in the data on den characteristics. These data also indicate the adaptability of grizzly bears in den site selection and a strong fidelity to denning areas. Although den re-use has been documented in many areas, it is not considered common; however, returning to a denning area is. These denning areas apparently possess characteristics that make them favorable, and some individuals remain traditional in using them (IGBC 1987).

PRE-DENNING AND POST-EMERGENCE

The activity of grizzly bears before denning and after emergence follows a predictable pattern that is determined by feeding behavior. The food habitats of Yellowstone grizzly bears are summarized in Knight et al. (1984) and Mattson et al. (1991). These investigations show that grizzly bears are opportunistic feeders that use a wide variety of animal and vegetal food items. Although diet varies as much by season as by month, trends are discernible. The main items in the diet of Yellowstone grizzly bears are whitebark pine nuts and ungulates. Grizzly bears obtain a substantial portion of their energy from ungulates in the spring (Mattson 1997). This food source is estimated to be one of the top two sources of energy in the average diet, especially during March, April, May, September, and October (Knight et al. 1984). Carrion scavenged from March through May constitutes a major portion of this ingested meat (Mattson et al. 1991), with peak availability of carcasses occurring around mid-April (Green 1994, Green et al. 1997).

In fall, bears aggressively forage to store fat for winter. This pursuit is called hyperphagia and is characterized by a determined attempt to increase calorie intake. The most important fall diet item for Yellowstone grizzly bears are whitebark pine seeds. Because the need for food is so intense, bears may approach areas of human activity that they would ordinarily avoid during this time when whitebark pine seeds are not available (Mattson 1990, Mattson et al. 1992).

In spring, bears leave their denning sites at higher elevations and search for carrion from winter-killed bison and elk. Therefore, key spring habitats for Yellowstone grizzly bears are ungulate winter ranges (Mattson 1997). Bear use of ungulate carcasses during spring varies among habitats. Green (1994) found that grizzly bear use of spring carcasses increased with elevation and that bears were more likely to use carcasses in the geothermally influenced habitats of the Firehole–Gibbon and Heart Lake areas than in the low-elevation areas of the Yellowstone northern range. This occurred even though most spring carrion in Yellowstone National Park was found on lower elevation ungulate winter range (Green 1994, Mattson 1997, Green et al. 1997).

Various studies have indicated that live ungulates are used as food when they are most available and vulnerable, as weakened animals during the spring (Henry and Mattson 1988, Green et al. 1997), as calves during May and June (Gunther and Renkin 1990), or as weakened bulls during the fall rut (Schleyer 1983). A few grizzlies have learned to kill adult elk during the summer (Servheen and Knight 1993).

Another high-energy diet item for Yellowstone grizzly bears following den emergence is whitebark pine seeds. Whitebark pine seeds are an energy-rich bear food typically found at higher elevation forest stands during the fall (Mattson and Reinhart 1994). However, after a high whitebark pine cone crop, cones will remain available during the following spring. As a result, bears will forage in these higher-elevation habitats, apparently preferring this food item to carrion (Mattson 1997, Green et al. 1997).

HUMAN ACTIVITIES

Judd et al. (1986) acknowledged that a deficiency in their investigation of grizzly bear denning activity in the GYA was the lack of insights gained on the impact of humans to bears during this period in their lives. The den sites they investigated were remote from humans at all times of the year, and there was no opportunity to address this issue.

One of the few studies that did deal with this topic was conducted in Alaska. It considered the impact of winter seismic surveys and small fixed-wing aircraft on denning grizzly bears (Reynolds et al. 1984). Grizzly bears used in the study were radio-collared or had heart-rate transmitters implanted. Potential sources of disturbance included the sounds of aircraft, sounds of operating vehicles (track-mounted drill rigs, geo-phone trucks, survey Bombardiers, snow machines, support trains), and sounds of shock waves associated with the detonation of about 85 pounds of dynamite at approximately 100 feet below the surface.

Detonations conducted within a range of 0.8 to 1.2 miles of the bears did not cause them to leave the den. However, movements within dens were sometimes detected following blasts (Reynolds et al. 1984). When seismic vehicles passed within 5/8 mile of the den, the bear's heart rate was elevated much more often than when undisturbed (Reynolds et al. 1984). Circumstantial evidence indicated that an unmarked bear left its den when seismic activity was within 650 feet of the den, but tractors and tracked vehicles came within 325 feet of a denned female with 3 yearlings without causing den abandonment. Mid-winter over-flights of dens with small fixed-wing aircraft did not change the heart rates of two females denning with young; however, flights conducted closer to the time of den emergence did change the heart rates of bears. The authors concluded that even if animals did respond to noises associated with seismic exploration activities, effects on them were probably minimal at these distances and at this level of activity (Reynolds et al. 1984). None of the radio-collared bears deserted dens, and there was no evidence of mortality.

Other research shows varying effects of human use on hibernating bears. Harding and Nagy (1980) documented grizzlies successfully denning on Richards Island, Northwest Territories, in the general area of hydrocarbon mining activity. Of the 35 dens they located, 28 were within the potential impact area, including several within one to four miles of active mine areas. However, Goodrich and Berger (1994) demonstrated that black bears abandoned den sites in response to disturbance.

Reynolds and Hechtel (1980) speculated that agitation within the den could have serious consequences for females with newborn cubs. Watts and Jonkel (1989) supported this idea and added that the ability of bears to reduce energy output in the winter may be a function of the secure den environment. In addition, human disturbance during denning could accelerate starvation and has resulted in den abandonment. They concluded that poor quality den sites and adverse weather could elevate metabolic rates and increase energy demands. Also, Geist (1978) discussed the implications of energy expenditure for animals and noted that when they are excited, the energetic costs from increased metabolism and heart rate can be significant. Presumably, this would hold true for bears in a den.

By their nature, dens represent locations where bears concentrate activities. This raises the concern of bear–human conflicts around dens. However, there are few documented cases of people being injured by bears in the vicinity of den sites. Herrero (1985) concluded this type of behavior may be due, in part, to the fact that dens are consistently in remote areas less traveled by people.

To a greater extent, grizzly bears may be affected by human activity while foraging during the pre- and post-denning periods. The pre-denning and post-emergence periods are critical times for bears. In the first time frame, they are in an intense feeding mode to store fat for the winter, and in the second time frame they are in search of food after depleting their reserves over the winter.

POTENTIAL EFFECTS

The literature indicates that bears can be impacted by human activities in winter. There are three stages in the annual cycle of the grizzly bear when it is vulnerable to the impacts of winter recreation use: (1) pre-denning, (2) denning, and (3) post-den emergence. Because of this, it is important to address a longer time frame than the traditional winter months. For example, the pre- and post-denning periods for bears overlap the fall and spring seasons, respectively. Therefore, it is reasonable to consider the pre- and post-denning time for bears as biological events instead of restricting an analysis of effects to calendar dates.

By the nature of how some recreational facilities are managed, winter visitor use generates effects on grizzly bears in the fall and spring that would otherwise not occur. The existence of winter-use facilities and programs likely encourage additional public visitation in the shoulder seasons. Winter recreational effects on bears are thus contingent on when and where facilities open in the fall and close in the spring.

Destruction of den sites or denning habitat does not appear to be a major issue in the GYA at present or in the near future. Neither does disturbing bears while they are preparing or occupying dens, although the possibility exists. The main concern is the potential for bear–human conflicts and displacement of bears while they are foraging during the pre-denning and post-emergence periods. Specifically, this involves bears engaged in wide-ranging foraging efforts before denning, mainly near whitebark pine habitats. It also includes the use of ungulate wintering areas by bears seeking carrion after leaving dens, and, to a lesser degree, bears using over-wintered whitebark pine seed crops at higher elevations.

Grizzly bears of the GYA may be affected by human winter recreation use of the following Potential Opportunity Areas:

(1) Destination areas. Human activity at destination areas has the potential to negatively impact grizzly bears. This

is primarily in the context of the pre- and post-denning periods. For example, spring surveys of grizzly bear habitats have shown that bears generally used carcasses less often than expected within 3 miles of a major park development (Green et al. 1997). Moreover, when bears come in proximity to park developments, more bear management actions and subsequently more grizzly bear removals occur (Mattson 1990, Reinhart and Mattson 1990).

Winter destination areas are becoming more popular. They include major ski areas, resorts, developments in Yellowstone National Park, and park gateway communities. These areas have been historic population sinks for grizzly bears in the GYA (Knight et al. 1988). The potential for bear–human conflicts is high when winter developments remain open after bears emerge from hibernation and are using spring habitats (approximately March 15) (Green et al. 1997). This is especially critical when these developments occur in or near areas where winter-killed ungulates and over-wintered pine nut crops may be found (Mattson et al. 1992).

In addition, bears will seek attractants around human developments in the pre-denning period of hyperphagia when food is less available. Frequently, the result is bear–human conflicts. Mattson et al. (1992) concluded there is a relationship between the quality of the fall pine nut crop and the number of conflicts that occur. During years of widespread pine nut use, grizzly bears are seldom found in proximity to human facilities. However, during years of little or no pine nut use, areas near human facilities (less than 3 miles from roads and 5 miles from developments) were used intensively by bears. Also, managers trapped nearly six times as many bears and nearly two times as many bears were killed during years of low pine nut production. Presumably, this was a consequence of bears being nearer and in more frequent contact with humans while seeking alternate foods to compensate for the lack of available pine nuts.

(2) Primary transportation routes and (3) scenic driving routes. Year-round roads will exist regardless of winter recreation use. However, winter recreational use management may cause changes in the amount of traffic a road receives. It may also be a catalyst for creating new roads.

Winter vehicle use of year-round roads during the denning period does not pose a risk to bears. Bears and traffic are spatially separated during most of the winter, and bear behavior seldom brings them into contact with the road corridor. Bear attractants along roads in the pre- and post-denning periods do present a risk. This could occur at roadside trash collection sites or as deliberate feeding of panhandling bears. An additional concern is road-killed animals (usually ungulates or rodents) that may attract bears to the roadside where they are vulnerable to vehicle collision.

(4) Groomed motorized routes and (5) motorized routes. Snowmobile traffic alone on highly and moderately groomed routes does not present a significant impact to bears during

most of the winter months. This is because of the predictability of defined snowmobile corridors and because most snowmobile use occurs during the time that bears are in hibernation. Conflict could occur when snowmobile use coincides with spring bear emergence and foraging. The potential for bear–human conflicts in Yellowstone National Park during the spring emergence is exacerbated by the fact that park roads are often located near thermal areas where ungulates congregate in the winter. The geothermally influenced ungulate winter ranges in the Firehole, Gibbon, and Norris areas are good examples of locations where the risk of bear–human conflict in the spring is high.

(6) Backcountry motorized areas. Most use of ungroomed snowmobile areas should not conflict with bear activity because it coincides with bear hibernation. Moreover, areas of ungroomed snowmobile use typically occur at elevations above bear spring habitats. An exception is when overwintered whitebark pine crops are available, and bears forage at high elevations in the spring. Another possible effect may occur because most backcountry snowmobile use occurs at higher elevations, where most bear denning is found.

The potential for conflicts between bears and recreational users does exist when dispersed use occurs after bear emergence (between March 1 and March 15).

(7) Groomed nonmotorized routes. Skiing along groomed routes does not present a significant impact to bears during most of the winter months. This is because of the predictability of defined ski corridors and the timing of most skiing coincides with bear hibernation. Conflict could occur when skiing is at the same time as bear foraging in the post-den emergence period.

(8) Nonmotorized routes. Skiing and snowshoeing along ungroomed routes does not present an impact to bears during most of the winter months. This is because of the timing of most of this travel coincident with bear hibernation. Conflict could occur when travel coincides with bear foraging in the post-den emergence period.

(9) Backcountry nonmotorized areas and (10) downhill sliding. Backcountry skiing, showshoeing, and downhill sliding should not present an impact to bears during most of the winter months. Again, the potential for bear–human conflicts may occur during the late winter period after bears emerge from hibernation. A component of this is the risk of human injury resulting from surprise encounters in backcountry areas as people disperse across the landscape in a manner unpredictable to bears (Herrero 1985). A unique expression of this occurs in low-elevation ungulate winter range where people search for dropped elk antlers. In this case, people intentionally canvas all parts of the terrain and concentrate on areas where wintering and winter-killed elk are found.

MANAGEMENT GUIDELINES

- (1) Destination areas. Early and mid-December and early and mid-March should be used as a time for transition from a fall to winter and winter to spring management strategy, respectively. Appropriate actions include closing facilities, restricting human use in sensitive areas, improving sanitation, and providing public education. Management of developments should reflect recognition of an increased potential each spring for bear–human conflicts and displacement of bears foraging within important habitats.

On public land, developments can be regulated, but it is more difficult to address activities at developments on private land. In these cases, coordinated sanitation programs involving private interests and government organizations are needed to remove attractants year-round, with a special emphasis placed on securing attractants during the pre-denning period.

- (2) Primary transportation routes and (3) scenic driving routes. Good roadside sanitation should be maintained. Signing to inform motorists of the need to secure attractants should be provided.

  Carcasses should be removed from the roadside between March 1 to November 30. No new roads to accommodate winter recreational use should be built in grizzly bear habitat as more access would ultimately result in more bear–human conflicts.
- (4) Groomed motorized routes and (5) motorized routes. Grooming and use of snowmobile roads and trails should end by March 15 in areas where post-denning bear activity is high.
- (6) Backcountry motorized areas. Where winter use occurs in ungulate wintering areas, activity should end by March 15. In areas with whitebark pine forests, a primary issue is the displacement of bears. Because the presence of over-wintered pine nut crops is not consistent, this is an episodic and not an annual concern. Therefore, travel restrictions should be addressed based on yearly monitoring rather than as a continuous restriction.
- (7) Groomed nonmotorized routes. Depending on the observed risk, grooming and use of these routes should end between March 1 and March 15 in those areas where bears would potentially be drawn to forage. Sanitation procedures around associated support facilities should be strengthened and public education initiated during the same time frame.
- (8) Nonmotorized routes. Use should be curtailed or restricted depending on the observed risk between March 1 to March 15. Public education should be initiated during the same time frame.
- (9) Backcountry nonmotorized areas and (10) downhill sliding. Use should be curtailed or restricted depending on the observed risk between March 1 to March 15. Public education should be initiated during the same time frame.

LITERATURE CITED

Craighead, J. J., K. R. Greer, R. R. Knight, H. I. Pac. 1988. Grizzly bear mortalities in the Yellowstone Ecosystem 1959–1987. Montana Fish, Wildlife, and Parks, Craighead Wildlands Institute, Interagency Grizzly Bear Study Team, National Fish and Wildlife Foundation, Bozeman, Montana, USA.

Eberhardt, L. L., B. M. Blanchard, and R. R. Knight. 1994. Population trend of the Yellowstone grizzly bear as estimated from reproductive and survival rates. Canadian Journal of Zoology 72:360–363.

———, and R. R. Knight. 1996. How many grizzlies in Yellowstone? Journal of Wildlife Management 60:416–421.

Geist, V. 1978. Chapter 19. Pages 28–296 *in* J. L. Schmidt and D. L. Gilbert, editors. Big game of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Goodrich, J. M., and J. Berger. 1994. Winter Recreation and hibernating black bears *(Ursus americanus)*. Biological Conservation 67:105–110.

Green, G. I. 1994. Use of spring carrion by bears in Yellowstone National Park. Thesis, University of Idaho, Moscow, Idaho, USA.

———, D. J. Mattson, and J. M. Peek. 1997. Spring feeding of ungulate carcasses by grizzly bears in Yellowstone National Park. Journal of Wildlife Management 61(4):1040–1055.

Gunther, K. A. 1994. Bear management in Yellowstone National Park, 1960–93. International Conference on Bear Research and Management 9:549–560.

———. 1996. Recovery parameters for grizzly bears in the Yellowstone ecosystem. Information paper Number BMO-6, Yellowstone National Park, Wyoming, USA.

———, and R. A. Renkin. 1990. Grizzly bear predation on elk calves and other fauna of Yellowstone National Park. International Conference on Bear Research and Management 8:329–334.

Harding, L., and J. A. Nagy. 1980. Responses of grizzly bears to hydrocarbon exploration on Richards Island, Northwest Territories. Canada International Conference on Bear Research and Management 4:277–280.

Henry, J., and D. J. Mattson. 1988. Spring grizzly bear use of ungulate carcasses in the Firehole River drainage: third year progress report. Pages 51–59 *in* Yellowstone grizzly bear investigations: annual report of the interagency study team, 1987. National Park Service, Bozeman, Montana, USA.

Herrero, S. 1985. Bear attacks: their causes and avoidance. Nick Lyons Books, New York, New York, USA.

IGBC (Interagency Grizzly Bear Committee). 1987. Grizzly bear compendium. The National Wildlife Federation. Washington, D.C., USA.

Judd, S. L., R. Knight, and B. Blanchard. 1986. Denning of grizzly bears in the Yellowstone National Park area. International Conference on Bear Research and Management 6:111–117.

Kendall, K. C., and S. F. Arno. 1990. Whitebark pine: an important but endangered wildlife resource. Pages 264–273 *in* W. C. Schmidt and K. J. McDonald, compilers. Proceedings of symposium on whitebark pine ecosystems: ecology and management of a high-mountain resource. U.S. Forest Service General Technical Report INT–270.

Knight, R. R., D. J. Mattson, and B. M. Blanchard. 1984. Movements and habitat use of the Yellowstone grizzly bear. Interagency Grizzly Bear Study Team, Montana State University, Bozeman, Montana, USA.

———, B. M. Blanchard, and L. L. Eberhardt. 1988. Mortality patterns and population sinks for Yellowstone grizzly bears, 1973–1985. Wildlife Society Bulletin 16:121–125.

Mattson, D. J. 1990. Human impacts on bear habitat use. International Conference on Bear Research and Management 8:33–56.

———. 1993. Background and proposed standards for managing grizzly bear habitat security in the Yellowstone ecosystem. Cooperative Park Studies Unit, University of Idaho, Moscow, Idaho, USA.

———. 1997. Use of ungulates by Yellowstone grizzly bears *(Ursus arctos)*. Biological Conservation 81:161–177.

———, and M. M. Reid. 1991. Conservation of the Yellowstone grizzly bear. Conservation Biology 5(3):364–372.

———, and D. P. Reinhart. 1994. Bear use of whitebark seeds in North America. Pages 212–220 *in* W. C. Schmidt and F. K. Holtmeier, editors. Proceedings of an international workshop on subalpine stone pines and their environments: the status of our knowledge. U.S. Forest Service General Technical Report INT-GTR-309.

Mattson, D. J., B. M. Blanchard, and R. R. Knight. 1991. Food habits of Yellowstone grizzly bears, 1977–87. Canadian Journal of Zoology 69:1619–1629.

———, ———, and ———. 1992. Yellowstone grizzly bear mortality, human habituation, and whitebark pine seed crops. Journal of Wildlife Management 56:432–442.

McNamee, T. 1984. The grizzly bear. Alfred A. Knopf, New York, New York, USA.

NPS (National Park Service). 1988. Final environmental impact statement, Fishing Bridge developed area. Appendix 6. Yellowstone National Park, Wyoming, USA.

Picton, H. D., D. J. Mattson, B. M. Blanchard, and R. R. Knight. 1985. Climate, carrying capacity, and the Yellowstone grizzly bear. Paper presented at the Grizzly Bear Habitat Symposium. Missoula, Montana, USA.

Povilitis, T. 1987. Grizzly bear mortality in Yellowstone: implications for conservation. Western Wildlands, Winter:15–18.

Reinhart, D. P., and D. J. Mattson. 1990. Bear use of cutthroat trout spawning streams in Yellowstone National Park. International Conference on Bear Research and Management 8:343–350.

Reynolds, H. V., and J. Hechtel. 1980. Big game investigations. Structure, status, reproductive biology, movements, distribution and habitat utilization of a grizzly bear population. Federal Aid Wildlife Restoration Project. W17-11, Job 4.14R. Job progress report, July 1, 1978–June 20, 1979. Alaska Department of Fish and Game, Juneau, Alaska, USA.

Reynolds, P. E., H. V. Reynolds, and E. H. Follmann. 1984. Responses of grizzly bears to seismic surveys in northern Alaska. International Conference on Bear Research and Management 6:169–175.

Schleyer, B. O. 1983. Activity patterns of grizzly bears in the Yellowstone ecosystem and their reproductive behavior, predation, and the use of carrion. Thesis, Montana State University, Bozeman, Montana, USA.

Schullery, P. 1992. The bears of Yellowstone. High Plains, Worland, Wyoming, USA.

Servheen, C., and R. R. Knight. 1993. Possible effects of a restored gray wolf population on grizzly bears in the Greater Yellowstone Area. U.S. Fish and Wildlife Service, Scientific Monograph 22, Missoula, Montana, USA.

USFWS (U.S. Fish and Wildlife Service). 1993. Grizzly bear recovery plan. Missoula, Montana, USA.

Varley, J. D., and P. Schullery, editors. 1995. The Yellowstone Lake crisis: confronting a lake trout invasion, a report to the Director of the National Park Service. Yellowstone Center for Resources, Yellowstone National Park, Wyoming, USA.

Watts, P. D., and C. Jonkel. 1989. Energetic cost of winter dormancy in grizzly bear. Journal of Wildlife Management 54(4):654–656.

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LYNX: THEIR ECOLOGY AND BIOLOGY AND HOW WINTER RECREATION EFFECTS THEM

POPULATION STATUS

Lynx *(Lynx canadensis)* historically occupied much of the northern portion of North America, but the loss and degradation of their habitat and the unregulated hunting and trapping that accompanied European settlement reduced their numbers and distribution in the conterminous United States (Jackson 1961, Ruediger 1994). Today, remnant lynx populations persist in some high-elevation boreal forests of the western and Great Lakes states, tied chiefly to the distribution and abundance of snowshoe hares (*Lepus americanus*) (Koehler and Aubrey 1994).

In 1999, the U.S. Fish and Wildlife Service (USFWS) is expected to list the lynx as a threatened species under the authority of the Endangered Species Act (ESA). The listing will culminate a series of actions that included a petition by conservation groups to list the species in 1992 and a series of court decisions. The action will require development of a recovery plan by the USFWS and also require that actions taken by federal wildlife and land-management agencies do not jeopardize the species' welfare. Lynx are already treated as a sensitive species by most federal and state wildlife management agencies in the western United States.

Montana is the only state in the contiguous United States that still allows trapping of lynx. There is currently a statewide quota of two lynx, with a limit of one per trapper per year. Trapper harvest peaked at 60 in 1979 but was reduced to two lynx per year by legislation. Trapper effort has also declined in spite of high lynx fur prices in the 1980s. Illegal and incidental harvest are thought to be negligible (Giddings et al. 1998).

Forest management practices and development of roads and human facilities may adversely affect lynx. However, the rarity and secretiveness of this species make its distribution and habitat requirements difficult to document (Ruediger 1994). The purpose of this report is to review and synthesize current literature on the effects of winter recreation on lynx within the Greater Yellowstone Area (GYA).

THE ABUNDANCE AND DISTRIBUTION OF LYNX IN YELLOWSTONE NATIONAL PARK

Although reliable information concerning the abundance and distribution of lynx is lacking, historical information suggests that this species was present but uncommon in Yellowstone National Park (YNP) from 1880 to 1980. This condition also describes the status of lynx in YNP today. Lynx were listed among animals that were present and seen by naturalists as early as the 1870s (Grinnell 1876, Blackburn 1879). Consolo Murphy and Meagher (In Press) documented the presence and distribution of lynx in YNP from 1893 to 1995 using sighting records, photographic records, and museum collections. They located 1 museum specimen of a female lynx, 34 sighting reports (39 total lynx), 17 observations of tracks, and 6 other forms of supportive evidence (*e.g.*, photographs). Lynx or their sign were observed parkwide, but visual observations were more common in the southern half of the park and tracks were more common in the north. Most (n=50) sightings and records of tracks occurred after 1930. Consolo Murphy and Meagher (In Press) included a reference to a hide from an illegally trapped lynx that was confiscated by park rangers near Norris Geyser Basin (Harris 1887). In addition to these records, 1 lynx was reported seen and 6 sets of lynx tracks were found in 1887 by T. Hofer, a pioneering naturalist and early visitor to the park (see *Field and Stream* 1887, April 7 to May 5 issues). Hofer's observations occurred at Norris Geyser Basin (tracks), Lower and Midway Geyser basins (tracks), Shoshone Lake (sighting), Alum Creek (tracks), and Canyon (tracks). *Yellowstone Nature Notes*, an in-house periodical of natural history observations made by YNP personnel, also contains 5 records of direct observations of lynx (7 total animals) spanning 1928 to 1958 that were not reported by Consolo Murphy and Meagher. More recently, Halfpenny (unpublished data) identified 1 set of lynx tracks near Snake Hot Springs in February 1979. From 1995 to present, 5 sightings of lynx were reported in YNP, 3 on the northern range and 2 in the park interior (K. A. Gunther, Yellowstone National Park, personal communication).

Unfortunately, records of lynx sightings or their tracks carry caveats with regard to reliability. YNP records prior to 1980 typically contained insufficient information to determine observer credibility and to estimate weather and lighting conditions. Consequently, misidentified animals may be represented in the data. In particular, inexperienced observers may easily confuse bobcats (*Lynx rufus*) with lynx.

Numerous researchers have attempted to document the presence of rare carnivores in YNP during this decade. Murphy (unpublished data) found no lynx sign while searching 7,500 km of transect on the northern winter range and vicinity from the winters 1987–88 to 1991–92 incident to cougar studies. No lynx were detected by Harter et al. (1993), who deployed 11 hair snares (387 trap nights) and 21 remote cameras (102 nights), and searched 16 track transects (116 km) on the northern winter range and vicinity from January to March 1993. Similarly, no lynx were found by Gehman et al. (1994), who deployed 20 hair snares (1,609 nights), 12 cameras (961 nights), and 31 track transects (200 km) from December 1993 to February 1994 on the northern winter range and vicinity. Finally, Gehman and Robinson (1998) did not detect lynx when they deployed 4 cameras (4 sites; approx. 138 nights) and 14 transects (80 total km) along the upper Gallatin River in YNP (see below for their sighting of a probable lynx track 10 km northwest of YNP).

THE PRESENCE AND DISTRIBUTION OF LYNX IN THE GYA

Museum, trapping, and other agency records indicate lynx distribution in the GYA prior to 1976 (Giddings et al. 1998; Fig. 1) with approximately 107, 6, and 8 occurrences of lynx in Wyoming, Montana, and Idaho, respectively (our counts from Giddings et al. 1998), including 8 records for Grand Teton National Park (GTNP). These records do not include a lynx killed in 1920 by ranger and his hounds in the Hellroaring Creek drainage (Stevenson 1920). In the GYA from 1976 to 1993, there are 122, 19, and 13 occurrences of lynx in Wyoming, Montana, and Idaho, respectively, including four records in GTNP. Lynx reports occur for the Absaroka, Beartooth, Centennial, Gallatin, Gros Ventre, Madison, Teton, Wind River, and Wyoming mountain ranges as well as forested portions of eastern Idaho (Giddings et al. 1998).

Laurion and Oakleaf (1998) surveyed 2,055 km of roads and 2,400 km of backcountry trails in 12 areas on the Shoshone (SNF) and Bridger–Teton (BTNF) national forests in western Wyoming during winter 1997–98. Lynx tracks were identified in three locales (four total track observations) on the SNF and one locale (two track observations) on the BTNF. In addition, D. Stevenson (1997) surveyed nine snow-covered transects 29 times (269 total km) near Bridger Lake, BTNF, from February to March 1997, but found no lynx sign. S. Patlas (Wyoming Game and Fish Department, personal communication) surveyed a total of 169 km of transect at nine locales in northern GTNP and vicinity but found no sign of lynx. However, citizen observers have recently seen lynx or their tracks near Big Piney, Kemmerer, Moose, and Dubois, in the Upper Greys River watershed, Wyoming (Laurion and Oakleaf 1998).

An adult male and a female lynx were captured in the Wyoming Range near Merna, Wyoming in 1996–97 as part of a research project being conducted by Wyoming Game and Fish Department (see Laurion and Oakleaf 1998). A total of five to seven lynx resided on the study area, including the radio-marked individuals. The radio-marked female produced four kittens during May 1998.

In Montana, Gehman and Robinson (1998) surveyed 12 snow-covered transects 39 times (170 total km) and deployed cameras at 15 different sites in the Gallatin National Forest in 1997–98. They identified a probable lynx track in Buck Creek, a tributary of the Gallatin River.

LIFE HISTORY

The breeding season for lynx spans March to May. Kittens are born in May or June after a 60- to 74-day gestation period. Young are born without teeth, but with closed eyes, folded ears, and a well-developed pelage. Lynx walk by age 24–30 days and are weaned at 3–6 months. However, kittens may consume meat as part of their diet by an age of 30 days. Kittens typically remain with their mothers until about age ten months, but the period of maternal care may extend into the next mating season. Females can breed at age ten months, but usually do not until 22 months.

Natural predators of lynx include coyotes *(Canis latrans)*, wolves *(Canis lupis)* (Banfield 1974), cougars *(Felis concolor)* (Koehler et al. 1979), wolverines *(Gulo gulo)*, and lynx themselves (Elsey 1954). Lynx contract rabies and distemper, but these diseases do not significantly affect their population dynamics. Dominant mortality factors are malnutrition and starvation of kittens (Brainerd 1985). Malnutrition may dispose lynx to disease and parasites (Quinn and Parker 1987).

SOCIAL ORGANIZATION AND SPACING PATTERNS

Lynx are solitary carnivores, remaining apart except when mating. Mothers support their altricial young without direct support of fathers. Spatial and temporal separation results from social intolerance and mutual avoidance that is accomplished through scent marking. Intersexual overlap for territories is high. During lows in hare numbers, adults of the same sex are mutually hostile, maintaining exclusive territories (Berrie 1973, Mech 1980). In a Washington study, strong territoriality may have resulted from a varied and relatively stable prey base (Koehler 1990a). As hare populations increase, social intolerance among lynx breaks down, prompting increases in the degree of range overlap (Slough and Mowat 1996). When hares are extremely scarce, lynx may become nomadic or emigrate.

Home range sizes differ by sex, prey density, and other factors. Females typically have home ranges that are smaller than males, varying from 10–243 km^2, but normally 15–20 km^2 in size. Home ranges varied from 36–122 km^2 for males in Montana (Koehler et al. 1979, Brainerd 1985). In Wyoming, a male's range was 131 km^2 and a female's was 137 km^2

(Laurion and Oakleaf 1998). In Alaska and Canada, home ranges may exceed 40–80 km^2 when hare populations decrease. Large ranges may indicate prey scarcity (Hatler 1988). Inverse relationships between hare numbers and the size of lynx ranges are documented (Brand et al. 1976, Ward and Krebs 1985, Poole 1993). Home ranges may be abandoned at a threshold of low hare densities, prompting lynx to turn nomadic (Ward 1985, Ward and Krebs 1985). The relatively large sizes of lynx home ranges in the Rocky Mountains suggests that the availability of snowshoe hares is low.

Lynx typically achieve densities of one per 15–25 km^2. In Washington, density was one per 40 km^2 (Koehler 1990a). Home range sizes and densities of lynx exhibit regional and local variation that depend on topography and food availability. When hare populations are low, lynx may concentrate in pockets of high hare density, leading to density estimates that are not representative for landscapes at a broad scale (Koehler and Aubrey 1994).

POPULATION DYNAMICS

Lynx generally occur at low density and are associated with boreal forest habitats. Their population dynamics are characterized by low reproductive rates and are strongly related to population dynamics of snowshoe hare, a keystone species that is the primary prey of lynx. In Canada, lynx populations fluctuate roughly on a ten-year cycle, lagging behind a similar cycle for snowshoe hares (Elton and Nicholson 1942, Keith 1963). While hare densities may change 200-fold, those of lynx change only up to 20-fold. One explanation is that lynx numbers are tied to a poorly understood interaction between hares and vegetation, with regional synchrony tied to weather effects.

Cycles may be muted or absent near the southern limits of the lynx's distribution (*i.e.*, in the conterminous U.S.), where hare populations apparently are more stable than those in Canada (Dolbeer and Clark 1975), possibly owing to greater diversity and stability in hare predators and competitors and the absence of adequate habitat during periods of hare lows. Snow-tracking surveys for hares in Montana showed a three-fold change in numbers of hare tracks from 1990 to 1998; lynx tracks varied eight-fold (Giddings et al. 1998). Consequently, dramatic differences in reproduction, habitat use, prey selection, dispersal, and vulnerability may exist between lynx populations in Canada and the conterminous U.S.

When hare populations crash, lynx may emigrate great distances, potentially making treks from Canada to the GYA. Dramatic increases in lynx numbers occurred in western Montana following peaks in the Canadian population during 1962–63 and 1971–72 (Hoffmann et al. 1969, Koehler and Aubrey 1994). Following the hare crash of the early 1970s, lynx populations apparently increased in Wyoming as suggested by the high trapper harvest in the Wyoming Range (Laurion and Oakleaf 1998). Immigrating lynx have large home ranges and little reproductive success. When hares are scarce, lynx may also concentrate in small areas making them vulnerable to human-caused mortality (Koehler and Aubrey 1994). Consequently, rapid declines in populations occur. For example, Minnesota trappers harvested 215 lynx in 1972, 691 in 1973, 88 in 1974, and 0 in 1975 (Mech 1980). Recovery from trapping exploitation may be slow when lynx are at low numbers (Laurion and Oakleaf 1998).

Lynx are characterized by fluctuating reproductive rates that are driven by food limitation. Females may not reproduce at all during food shortages. In Montana, pregnancy rates of adult females reached 90 percent, but declined to 33 percent when food was scarce (Giddings 1994). Litters of adult females averaged 3.2 kittens and those of yearlings averaged 1.7 (Brainerd 1985) or 2.7 (Giddings 1994). In the GYA, one female had four kittens (Laurion and Oakleaf 1998). In general, population dynamics of lynx are affected more by failure to produce litters than the size of litters.

Food availability directly correlates with the survival of young lynx. Few kittens survive when food is scarce, with the result that recruitment of offspring to the breeding population is low to non-existent (Koehler 1990a). In the Wyoming Range, Laurion and Oakleaf (1998) found that few kittens survived through the summer.

Lynx may disperse long distances from their natal area. Dispersal distances for females range from 103–250 km and from 164–1,100 km for males (Slough and Mowat 1996). One female from Montana moved 325 km to British Columbia (Brainerd 1985). Previously territorial adults may become transient if prey bases become reduced. Most dispersers are young animals in search of unoccupied territories.

FOOD HABITS

Snowshoe hares constitute the main portion of the lynx's diet, about 60 percent in winter and 40 percent in summer. Other prey include squirrels (*Tamiasciurus hudsonicus*), voles (*Clethrionomys* spp. and *Microtus* spp.), mice (*Peromyscus* spp.), grouse (*Bonasa* spp. and *Dendragapus* spp.), ptarmigan (*Lagopus* spp.), and other birds. While not important predators of ungulates, lynx occasionally may kill adult deer (*Odocoileus* spp.) and moose (*Alces alces*) in poor physical condition or when snow conditions are favorable for predation or when ungulate offspring are available. Although chiefly an obligate predator, lynx will scavenge carcasses and eat vegetation.

Lynx take a variety of mammals when hares are scarce, but only hares support high population densities of lynx (Koehler 1990b). Kill rates average about two hares per three days, but rates vary with prey density. Food consumption may be 37 percent lower when hares are scarce (Brand et al. 1976). Food caching has been reported, particularly when prey is scarce.

HABITAT REQUIREMENTS

In Wyoming, lynx occur primarily in spruce-fir and lodgepole pine forests that slope at 8–12° at elevations between 2,437 and 2,937 m. For denning, lynx often select mature stands (250 years or older) of Engelmann spruce (*Picea engelmanni*), subalpine fir (*Abies bifolia*), and lodgepole pine (*Pinus contorta*) on north or northeast slopes and prefer sites larger than 30 acres in size with more than 80 downed logs (>20 inches diam.) per acre on north or east aspects. Old-growth spruce forests that have escaped natural fires in landscapes that are otherwise dominated by lodgepole pine also provide ideal denning habitat. Denning habitat is enhanced if forest parcels contain numerous alternate den sites and/or they are connected to other denning habitats (Koehler and Aubrey 1994, Tanimoto 1998). Dens are often located in hollow logs or in brush piles, particularly where surrounded by dense thickets. Downed logs 40–50 m in length provide escape cover for young kittens (Koehler 1990a, Koehler and Brittell 1990). Security cover is also necessary for diurnal rest areas used by adults and kittens that no longer use dens. Diurnal bed sites frequently occur in thickets near game trails.

Lynx are specialized predators that hunt in habitats preferred by snowshoe hares. Hares require densely stocked stands of deciduous shrubs or young conifers (*e.g.*, lodgepole pine

<2.5 cm dbh) (Koehler and Brittel 1990) for forage, escapes routes, and thermal cover. Hare abundance is positively correlated with the density of cover at 1–3 m above ground or snow. Hare food is typically woody browse smaller than 4 mm in diameter that is less than 60 cm above the ground or snow. Stands that reach densities of 16,000 stems per ha are ideal (Keith et al. 1984). The structural attributes of vegetation needed by hares can be achieved in less than 20 years of growth and serial succession in the moist forests of Oregon and Washington. However, these conditions may not be achieved for 80 years or longer in the GYA.

Hares require a diversity of food items, foraging on birch (*Betula* sp.), poplar (*Populus* sp.), willow (*Salix* sp.), and conifers. Pines are preferred to spruce, and spruce is preferred to fir. Because the nutrient content and palatability of forage decreases with increasing stem diameter, hares must browse selectively, consuming about 300 g per day, and cannot compensate for low food quality by increasing their consumption. Aspen (*P. tremuloides*) stands and forest edges, as well as open grass meadows and edges with forests, may also support high numbers of hares and lynx. At the southern extent of lynx range, Colorado lynx were found near upper treeline in mature spruce-fir habitats where the forest and tundra edges provided food for hares (Halfpenny and Miller 1981; Halfpenny and Thompson 1987; Thompson and Halfpenny 1989, 1991).

Hares feed on buds, young branches, and tips of older trees. Forage must be above the snow (hares do not excavate), but not out of reach. Heavy snowfall may bend small trees, increasing forage for hares (Koehler et al. 1979, Koehler 1990b, Koehler and Brittell 1990). Deer, elk, and moose often reduce browse available to hares at ground level, particularly where wintering ungulates concentrate in or near habitats used by hares (Olson 1957; Telfer 1972, 1974).

Lynx denning and hunting habitat must be connected by corridors providing cover for travel. Corridors used by lynx include tops of ridges and riparian zones with more than 30 percent canopy cover provided by subalpine fir, spruce, and lodgepole pine. Corridors should be at least 100 m in width and contain at least 300 stems per acre (Ruediger 1994). Lynx will cross narrower openings but will rarely hunt in them.

On a landscape scale, lynx habitat includes a mosaic of early seral stages that support snowshoe hare populations and late seral stages of dense old growth forest that is not heavily fragmented by logging, roads, reservoirs, train tracks, or other developments. Connectivity between lynx populations is critical. Dispersal corridors should be several miles wide with only narrow gaps. Large tracts of continuous coniferous forest are the most desirable for lynx travel and dispersal (Tanimoto 1998).

INTERSPECIFIC INTERACTIONS

Lynx may compete with canids, other felids, mustelids, and raptors for snowshoe hares and small mammals. Bobcat home ranges often exhibit elevational separation from those of lynx, which are better adapted to deep snow. Bobcats are thought to displace lynx where both felids are locally sympatric. However, lynx occasionally may kill bobcats (Giddings et al. 1998).

EFFECTS OF WINTER RECREATION ON LYNX

Winter recreation has cultural, economic, and social aspects that may affect lynx both directly and indirectly. With respect to winter recreation, direct effects are those that change the survival of individuals. Losses resulting from lynx trapping, non-target trapping, or accidental deaths (*e.g.*, hit by cars) are examples of direct effects. Losses or degradation of habitat through habitat destruction or disturbance are examples of indirect effects. Because both direct and indirect effects influence vital rates (*e.g.*, natality and survival), they may strongly influence the viability of lynx populations.

Because of the secretive nature of lynx and their habit of using deep-forest habitats, few ecological studies of lynx exist, let alone research on the effects of winter recreation. However, the paucity of data should not be construed as evidence that winter recreation has no adverse effects on this species.

DIRECT EFFECTS

Trapping seasons may significantly reduce the viability of lynx populations, particularly if lynx are few and/or key breeding individuals are removed. Currently, Montana is the only state in which lynx may be legally trapped, but very few are taken in the Montana portion of the GYA. In all states of the Yellowstone ecosystem, lynx may also be killed incidentally by bobcat trappers and hunters that are unable to distinguish the two felids when observed directly (Todd 1985, Bailey et al. 1986, Koehler and Aubrey 1994, Giddings et al. 1998). In addition, houndsmen may chase lynx with their dogs after mistaking lynx tracks for those of bobcats or cougar.

Roads and snowmobile trails are an important aspect of winter recreation because they provide people with their principal access to wildlands. The type, density, and distribution of roads and trails in lynx habitat affect the probability that trappers will locate lynx tracks and legally take them in traps. Roads also affect the rate at which lynx are killed, incidentally by trappers and/or illegally by hunters or houndsmen. Thompson (1987) noted that all known lynx sightings on Vail Mountain Ski Area, Colorado, were animals that were shot (n=1) or illegally trapped (n=2). Easy access to lynx habitat is particularly detrimental when pelt prices are high or recruitment of young lynx to the breeding population is low (Koehler and Aubrey 1994).

No road-killed lynx have been documented in the GYA, but losses of coyotes, wolves, cougars, and black and grizzly bears are well documented (Caslick and Caslick 1997, Gunther et al. 1998). During an attempted restoration of lynx in New York, 22 percent of introduced animals were killed by automobiles (Brocke et al. 1992, Weaver 1993).

Lynx behavior may predispose them to collisions with vehicles, especially when emigrating, hunting, or travelling (Weaver 1993). Road edges and train tracks support exposed forbs, grasses, and shrubs during winter; these locations are suited to foraging snowshoe hares, mice, voles, and other small mammals. Consequently, these sites are also excellent hunting areas for lynx (Koehler and Aubrey 1994). During winter, lynx frequently travel along roads where adequate cover is available on both shoulders (Koehler and Aubrey 1994).

INDIRECT EFFECTS

Humans alter the structure, biotic composition, and arrangement of habitat components that are essential to lynx. Winter recreation and its associated infrastructure reduces the amount of suitable habitat available to lynx and reduces the effectiveness of pristine habitat because human disturbance causes lynx to avoid habitats that are otherwise suitable.

Habitat Destruction.—Development of resort and other destination infrastructure for winter recreationists destroys and fragments lynx habitat. Human populations in the ten counties comprising the GYE increased 7.4 percent from 1980 to 1990, while the number of households increased 8.4 percent (Feigley 1993). Although only a fraction of this development occurred in habitats potentially used by lynx, road and housing development in expanding recreation-based communities such as West Yellowstone and Big Sky, Montana, and Old Faithful, Wyoming, could represent a significant cumulative loss of lynx habitat. In addition, the highways and improved roads that connect these communities also represent habitat losses because the improved surface, particularly for wide roads (>15 m), is essentially unusable by lynx except for aforementioned opportunities to travel or hunt along the road shoulder.

Loss of Habitat Effectiveness Resulting From Disturbance.—Human disturbance associated with recreational infrastructure and roads can reduce the effectiveness of habitat in supporting lynx, even if habitat is otherwise of high quality. Losses of habitat effectiveness can be adverse because disturbances preclude lynx from using habitat in an optimal manner. Lynx and other wildlife may avoid developments and roads because of the association with humans, particularly if they are unfamiliar with the sights, sounds, and smells that accompany human activity (Gutzwiller 1995).

The paucity of studies makes it difficult to assess the magnitude of disturbance and displacement associated with winter recreation. Year-round, ungulates that are not habituated to humans adjust their distribution and activity patterns to avoid human activity (Lyon 1979, Aune 1981, Rost and Bailey 1979, Edge et al. 1985, Kufeld et al. 1988, Cassirer et al. 1992, Caslick and Caslick 1997). Displacement, including den abandonment, is documented for black bears (*Ursus americanus*) and grizzly bears (*U. arctos*) (Jonkel 1980, Goodrich and Berger 1994).

The search for cross-country and downhill skiing opportunities leads recreational skiers to prime lynx habitat. Downhill and cross-country ski development destroys and fragments lynx habitat and increases disturbance associated with human traffic, thereby reducing habitat security for lynx (Halfpenny and Miller 1981; Thompson 1987; Halfpenny and Thompson 1987; Thompson and Halfpenny 1989, 1991; Halfpenny 1991). Development of winter ski areas may also increase disturbance of lynx in the off-season, as recreational use and maintenance activity will occur year-round.

Snowmobiling may be particularly adverse to lynx because: (1) this activity occurs when animals are frequently in poor condition due to the stresses of winter (Anderson 1995); (2) this activity may be dispersed on the landscape (*i.e.*, not confined to roads) on national forest lands outside of wilderness areas; (3) it may occur at night when lynx are usually active; (4) it is frequently accompanied by human disturbance and habitat loss associated with recreational infrastructure; and (5) this activity may alter the density and distribution of snowshoe hares, a favored prey item. In Ontario, Canada, snowmobile activity altered the mobility, distribution, and movements of hares (Neuman and Merriam 1972). Road plowing, grooming, and construction activities that support snowmobilers may also significantly reduce the effectiveness of winter lynx habitats. In this regard, road density and the level of automobile use are important considerations because they affect the frequency and intensity of disturbance.

Disturbance, however, does not necessarily lead to a continued reduction in habitat effectiveness for lynx. With repeated exposure to human activity that is predictable in time and space, lynx may adapt behaviorally or physiologically (Bowles 1995). Lynx visited Geneva Basin and Vail Ski areas in Colorado at night to scavenge at garbage dumps (Halfpenny et al. 1982; Thompson 1987; Thompson and Halfpenny 1989, 1991). Lynx also used ski runs at Vail from adjacent non-developed habitat, despite night grooming operations (Thompson and Halfpenny 1989, 1991). Lynx also visited a night-active winter construction camp on the Frying Pan River in Colorado, presumably scrounging for garbage (J. Halfpenny, unpublished data).

Non-motorized recreational activities, such as backcountry cross-country skiing or snowshoeing, may affect lynx, particularly because the disturbance associated with these activities is often dispersed and unpredictable to mammals. Surprisingly, disturbance by people may have a greater negative effect than motorized vehicles on established roadways because mammals habituate more quickly to mechanical noise than to noises of humans (Schultz and Bailey 1978, Aune 1981, Cassirer et al. 1992, Gabrielsen and Smith 1995). Laughing and yelling can arouse responses of mammals at greater distances than snowmobile noise (Bowles 1995).

The cumulative impacts of dispersed winter recreation must also be considered. For example, the adverse effects of motorized recreation in one habitat may be additive to adverse effects of housing infrastructure elsewhere in an ecosystem. Consequently, the potential effects of all recreational activity should be considered together in cases where a single lynx population or a lynx metapopulation is present. In Colorado, the development of three potential ski areas (Wolf Creek Pass, Wolf Creek, and East Fork of the San Juan) in lynx habitat could have resulted in habitat destruction and alteration at each site, as well as reduced habitat suitability within the triangle among ski areas because of increased access and habitat size reduction (Halfpenny 1991).

One other relationship between winter recreation and lynx deserves consideration: the cumulative effect of human activity on the survival of lynx and their population viability during periods when hare populations are low. Stresses associated with winter recreation might force lynx across a mortality or reproductive threshold, leading to population declines and extirpation of local populations. As previously mentioned, female lynx fail to produce litters or have reduced litter sizes during periods of food limitation. Kittens may also frequently die of malnutrition during winter due to the stresses incurred during this season. Thus, reduced recruitment of breeding individuals during periods of hare shortages contributes directly to dramatic declines in lynx populations. Disturbance of wintering lynx may cause them to expend energy beyond their caloric intake, decreasing natality and increasing mortality. When a disturbance occurs over a large area, Anderson (1995) suggests animal populations could be extirpated in a single winter. Thereafter, food limitation and human disturbance may delay successful recolonization of the area.

MANAGEMENT GUIDELINES

Lynx are very specialized carnivores, requiring snowshoe hares as part of their diet and mature conifer-fir forests for denning. Because of these requirements, lynx are potentially affected by snow-based recreational activities that occur in cold forest habitats. Winter recreation at Potential Opportunity Areas in the GYA may affect lynx as described below.

(1) Destination areas. Human activity at destination areas has the potential to affect lynx, as this species both uses and avoids habitats near human facilities (Halfpenny et al. 1982). Displacement of lynx from winter habitat is an important management concern. Use of ski areas, other resorts, and communities is increasing in the GYA. New developments, or significant increases in existing developments, destroy at least some

lynx habitat and may cause lynx to increase avoidance of habitats that are immediately peripheral to these sites. Downhill ski areas should be designed to reduce impacts on lynx by reducing habitat fragmentation and providing security zones between activity locations (Thompson 1987). Lynx may also habituate to human foods, potentially increasing management problems and lynx mortality. Proper garbage and food storage would reduce unnatural attractants and management actions.

(2) Primary transportation routes and (3) scenic driving routes. Roads, whether they are maintained or unmaintained, provide recreational access. Increased demand for winter recreation may be a catalyst for creating new roads. Roads may increase lynx mortality due to trapping pressure and collisions with vehicles. The road density and traffic volume may indirectly influence levels of lynx mortality. Disturbance associated with automobiles, snowmobiles, and recreationists may pose a risk to denning lynx. More roads may ultimately reduce habitat effectiveness for lynx and increase habitat fragmentation.

(4) Groomed motorized routes. Snowmobile traffic may reduce the effectiveness of lynx habitats that are peripheral to groomed snowmobile routes. Lynx and hares that use habitats in the vicinity of roads may be adversely stressed by disturbance. Night use of roads may be more detrimental than day use because lynx are nocturnal and crepuscular. However, lynx may show some habituation to snowmobile activity where it is temporally and spatially consistent. Restrictions on quantity and timing of snowmobile travel could reduce adverse effects on lynx.

(6) Backcountry motorized areas. Snowmobiles are frequently used in the backcountry at high elevations, often within or near lynx habitat. Because this activity is highly obtrusive and usually dispersed on the landscape, it has a strong potential to displace lynx from their winter haunts, increase stress levels, and reduce the fitness and viability of lynx populations (Cole and Landres 1995).

(7) Groomed nonmotorized routes. Skiing on groomed routes may affect lynx when the activity occurs at high levels. Therefore, skiers should be directed away from high-quality lynx habitat, particularly where lynx are already known to exist.

(8) Nonmotorized routes. Skiing and snowshoeing along ungroomed routes could affect lynx where people use trails frequently. Typically, lynx will not be frequently disturbed by these activities because use of ungroomed trails in the GYA, particularly in deep-forest habitats, is still relatively uncommon. However, forest managers may need to restrict access to prime lynx habitat.

(9) Backcountry nonmotorized areas. Dispersed activities such as backcountry skiing, snowshoeing, and camping have the potential to disturb lynx, but these activities may not be adverse because they occur at low levels in the GYA.

NEEDS FOR MANAGEMENT-RELATED MONITORING AND RESEARCH

Managers should develop a GIS-based inventory of snowshoe hare and lynx habitat. Aerial mapping efforts should be supplemented with ground-based work that includes density estimates of snowshoe hare derived from track surveys and pellet counts. The effects of winter recreation and associated off-season activities should be assessed in the context of cumulative effects at scales applicable to lynx populations and landscapes.

Existing knowledge on the distribution, abundance, demography, and habitat requirements is grossly inadequate to conserve lynx populations. A detection and monitoring system for lynx should be developed using ground-based track surveys (*e.g.*, Halfpenny et al. 1995) or cheek-rub carpet patches (J. Weaver, personal communication; Turbak 1998). Surveys should be repeated systematically over time to detect short-term and long-term changes in the distribution and abundance of lynx.

The rarity of lynx in the GYA dictates a conservative approach to managing lynx and their habitat. Maintaining corridors for possible lynx (and other wildlife) migration from northern Montana or Canada would facilitate conservation of this species.

LITERATURE CITED

Anderson, S. H. 1995. Recreational disturbance and wildlife populations. Pages 157–168 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C., USA.

Aune, K. E. 1981. Impact of winter recreationists on wildlife in a portion of Yellowstone National Park, Wyoming. Thesis, Montana State University, Bozeman, Montana, USA.

Bailey, T. N., E. E. Bangs, M. F. Portner. 1986. Apparent overexploited lynx population on the Kenai Peninsula, Alaska. Journal of Wildlife Management 50:279–290.

Banfield, A. W. F. 1974. The mammals of Canada. University Toronto Press, Toronto, Ontario, Canada.

Berrie, P. M. 1973. Ecology and status of the lynx in interior Alaska. The World's Cats 1:4–41.

Blackburn, C. F. 1879. The wilderness at the head of the Missouri, Columbia, and Colorado rivers. Scientific American Supplement 8:2903–2904.

Bowles, A. E. 1995. Responses of wildlife to noise. Pages 109–156 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C., USA.

Brainerd, S. M. 1985. Reproductive ecology of bobcats and lynx in western Montana. Thesis, University of Montana, Missoula, Montana, USA.

Brand, C. J., L. B. Keith, and C. A. Fischer. 1976. Lynx responses to changing snowshoe hare densities in central Alberta. Journal of Wildlife Management 40:416–428.

Brocke, R. H., K. A. Gustafson, and L. B. Fox. 1992. Restoration of large predators: potential and problems. Pages 303–315 *in* D. J. Decker, M. E. Krasny, G. R. Goff, C. R. Smith, and D. W. Gross, editors. Challenges in the conservation of biological resources, a practitioner's guide. Westview Press, Boulder, Colorado, USA.

Caslick, J. W., and E. Caslick. 1997. Selected literature citations from Bennett 1995 and new citations from Caslick 1997 on winter recreation effects on wildlife. Unpublished report. National Park Service, Yellowstone National Park, Wyoming, USA.

Cassirer, E. F., D. J. Freddy, and E. D. Ables. 1992. Elk responses to disturbance by cross-country skiers in Yellowstone National Park. Wildlife Society Bulletin 20:375–381.

Cole, D. N., and P. B. Landres. 1995. Indirect effects of recreationists on wildlife. Pages 183–202 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C., USA.

Consolo Murphy, S. L., and M. Meagher. In Press. The status of wolverine, lynx, and fisher in Yellowstone National Park. Proceedings of the third biennial science conference on the greater Yellowstone ecosystem, Yellowstone National Park. Northern Rockies Conservation Cooperative, Jackson, Wyoming, USA.

Dolbeer, R. A., and W. R. Clark. 1975. Population ecology of snowshoe hares in the central Rocky Mountains. Journal of Wildlife Management 39:535–549.

Edge, W. D., C. L. Marcum, and S. L. Olson. 1985. Effects of logging activities on home-range fidelity of elk. Journal of Wildlife Management 49:741–744.

Elsey, C. A. 1954. A cause of cannibalism in Canada lynx (*Lynx canadensis*). Journal of Mammalogy 35:129.

Elton, C., and M. Nicholson. 1942. The ten-year cycle in numbers of the lynx in Canada. Journal of Animal Ecology 11:215–244.

Feigley, H. P. 1993. Comments on the large carnivore conservation problem. Pages 43–46 *in* T. W. Clark, A. P. Curley, and R. P. Reading, editors. Conserving threatened carnivores: developing interdisciplinary problem-oriented strategies. Northern Rockies Conservation Cooperative, Jackson, Wyoming, USA.

Gabrielsen, G. W., and E. N. Smith. 1995. Physiological responses of wildlife to disturbance. Pages 95–107 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C., USA.

Gehman, S., and B. Robinson. 1998. Rare carnivore surveys. Annual project report. Yellowstone Ecosystem Studies, Bozeman, Montana, USA.

———, B. Crabtree, and S. Consolo Murphy. 1994. Northern Yellowstone carnivore study: winter 1993–94. Annual project report. Yellowstone Ecosystem Studies, Bozeman, Montana, USA.

Giddings, B. 1994. Population status of lynx in Montana. Unpublished report. Montana Fish, Wildlife and Parks, Helena, Montana, USA.

———, W. Melquist, B. Oakleaf, and B. Bates. 1998. An assessment of lynx in the northern Rocky Mountains: a response to the U.S. Fish and Wildlife Service request for information concerning the proposed rule to list the contiguous U.S. population of lynx as a threatened species. Montana Fish, Wildlife and Parks, Helena, Montana, USA.

Goodrich, J. M., and J. Berger. 1994. Winter recreation and hibernating black bears (*Ursus americanus*). Biological Conservation 67(2):105.

Grinnell, G. B. 1876. Zoological report. Pages 63–71 *in* W. Ludlow. Report of a reconnaissance from Carroll, Montana Territory, on the Upper Missouri to the Yellowstone National Park, and return made in the summer of 1875. U.S. Government Printing Office, Washington, D.C., USA.

Gunther, K. A., M. J. Biel, and H. L. Robison. 1998. Factors influencing the frequency of road killed wildlife in Yellowstone National Park. Pages 32–42 *in* G. L. Evink, P. Garrett, D. Ziegler, and J. Berry, editors. Proceedings of the International Conference on Wildlife Ecology and Transportation, FL-ER-69S58. Fort Meyers, Florida, USA.

Gutzwiller, K. J. 1995. Recreational disturbance and wildlife communities. Pages 169–181 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C., USA.

Halfpenny, J. C. 1991. Predator survey for East Fork of the San Juan River Ski Area. Unpublished field notes. A Naturalist's World, Gardiner, Montana, USA.

———, and G. C. Miller. 1981. Lynx and wolverine verification. Wildlife Resources Report, Part I. Colorado Division of Wildlife, Denver, Colorado, USA.

———, and R. W. Thompson. 1987. Predator survey with emphasis on wolverine and lynx for Quail Mountain Ski Area, Colorado. Unpublished report. Western Ecosystems, Lafayette, Colorado, USA.

———, S. J. Bissell, and D. Nead. 1982. Southern limits of lynx distribution with special reference to Colorado. Unpublished report. Colorado Division of Wildlife, Denver, Colorado, USA.

———, ———, S. C. Morse, T. Holden, and P. Rezendes. 1995. Snow tracking. Pages 91–163 *in* W. J. Zielinski and T. E. Kucera, editors. American marten, fisher, lynx, and wolverine: survey management strategy for British Columbia. British Columbia Ministry of Environment, Victoria, British Columbia, Canada.

Harris, M. 1887. Report of the Superintendent of Yellowstone National Park. National Park Service, Yellowstone National Park Library, Yellowstone National Park, Wyoming, USA.

Harter, M., B. Crabtree, and S. Consolo Murphy. 1993. Northern Yellowstone carnivore survey: winter 1992–1993. Yellowstone Center for Resources annual report. National Park Service, Yellowstone National Park, Wyoming, USA.

Hatler, D. F. 1988. A lynx management strategy for British Columbia. Wildlife Bulletin Number 61. British Columbia Ministry of Environment, Victoria, British Columbia, Canada.

Hoffmann, R. S., P. L. Wright, and F. E. Newby. 1969. The distribution of some mammals in Montana. Part 1: mammals other than bats. Journal of Mammalogy 50:579–604.

Jackson, H. H. T. 1961. Mammals of Wisconsin. University of Wisconsin Press, Madison, Wisconsin, USA.

Jonkel, C. 1980. Winter disturbance and grizzly bears. Special Report Number 46. Border Grizzly Project, University of Montana, Missoula, Montana, USA.

Keith, L. B. 1963. Wildlife's ten-year cycle. University of Wisconsin Press, Madison, Wisconsin, USA.

———, J. R. Cary, O. J Rongstad, and M. C. Brittingham. 1984. Demography and ecology of a declining snowshoe hare population. Wildlife Monograph Number 90.

Koehler, G. M. 1990a. Population and habitat characteristics of lynx and snowshoe hares in north central Washington. Canadian Journal of Zoology 68:845–851.

———. 1990b. Snowshoe hare, *Lepus americanus*, use of forest successional stages and population changes during 1985–1989 in north-central Washington. Canadian Field Naturalist 105:291–293.

———, and J. D. Brittell. 1990. Managing spruce-fir habitat for lynx and snowshoe hares. Journal of Forestry 88:10–14.

———, and K. B. Aubrey. 1994. Lynx. Pages 74–98 *in* L. F. Ruggiero, K. B. Aubrey, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski, editors. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the Western United States. General Technical Report RM-254. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

———, M. Hornocker, and H. Hash. 1979. Lynx movements and habitat use in Montana. Canadian Field Naturalist 93:441–442.

Kufeld, R. C., D. C. Bowden, and D. L. Schrupp. 1988. Influence of hunting on movements of female mule deer. Journal of Range Management 41:70–72.

Laurion, T., and B. Oakleaf. 1998. Wyoming Lynx Inventories. Unpublished report. Wyoming Game and Fish Department, Cheyenne, Wyoming, USA.

Lyon, L. J. 1979. Habitat effectiveness for elk as influenced by roads and cover. Journal of Forestry 77:658–660.

Mech, L. D. 1980. Age, sex, reproduction, and spatial organization of lynx colonizing northeastern Minnesota. Journal of Mammalogy 61:261–267.

Neumann, P. W., and H. G. Merriam. 1972. Ecological effects of snowmobiles. Canadian Field Naturalist 86:207–212.

Olson, P. F. 1957. Deer-snowshoe hare competition. Unpublished report. Michigan Department of Conservation, Houghton, Michigan, USA.

Poole, K. G. 1993. Northwest Territories lynx study overview: survival during and after the hare crash. Seventh Northern Furbearer Conference. Yukon Department of Renewable Resources, Whitehorse, Yukon, Canada.

Quinn, N. W. S., and G. Parker. 1987. Lynx. Pages 682–685 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario, Canada.

Rost, G. R., and J. A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. Journal of Wildlife Management 43:634–641.

Ruediger, B. 1994. Wolverine, lynx, and fisher habitat and distribution maps: draft hierarchical approach and draft conservation strategies. Letter to forest supervisors, regional foresters, and cooperating agencies. U.S. Forest Service, Missoula, Montana, USA.

Shultz, R. D., and J. A. Bailey. 1978. Responses of national park elk to human activity. Journal of Wildlife Management 42:91–100.

Slough, B. G., and G. Mowat. 1996. Lynx population dynamics in an untrapped refugium. Journal of Wildlife Management 24:495–499.

Stevenson, D. 1997. Forest carnivore survey results—Bridger Lakes area, 2/21/97–3/22/97. Letter to Bob Oakleaf. Wyoming Game and Fish Department, Lander, Wyoming, USA.

Stevenson, D. 1920. Unpublished report on game studies detail (incomplete). On file, National Park Service, Yellowstone National Park archives, Yellowstone National Park, Wyoming, USA.

Tanimoto, P. D. 1998. Lynx management assessment and comment to the U.S. Fish and Wildlife Service's proposal to list lynx under the Endangered Species Act of 1973. Unpublished report. Predator Project, Bozeman, Montana, USA.

Telfer, E. S. 1972. Browse selection by deer and hares. Journal of Wildlife Management 36:1344–1349.

———. 1974. Vertical distribution of cervid and snowshoe hare browsing. Journal of Wildlife Management 38:939–942.

Thompson, R. W. 1987. Guidelines for expansion of Vail Ski area into potential Canada lynx habitat. Unpublished report. Western Ecosystems, Lafayette, Colorado, USA.

———, and J. H. Halfpenny. 1989. Canada lynx presence on the Vail ski area and proposed expansion areas. Unpublished report. Western Ecosystems, Lafayette, Colorado, USA.

———, and ———. 1991. Canada lynx presence on the proposed East Fork ski area. Unpublished report. Western Ecosystems, Boulder, Colorado, USA.

Todd, A. W. 1985. The Canada lynx: ecology and management. Canadian Trapper 13:15–20.

Turbak, G. 1998. Seeking the missing lynx. National Wildlife December/January:19–24.

Ward, R. M. P. 1985. Behavioral responses of lynx to declining snowshoe hare abundance. Thesis, University of British Columbia, Vancouver, British Columbia, Canada.

———, and C. J. Krebs. 1985. Behavioral responses of lynx to declining snowshoe hare abundance. Canadian Journal of Zoology 63:2817–2824.

Weaver, J. 1993. Lynx, wolverine, and fisher in the western United States: research assessment and agenda. Unpublished report. Northern Rockies Conservation Cooperative, Jackson, Wyoming, USA.

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EFFECTS OF WINTER RECREATION ON MID-SIZED CARNIVORES (WOLVERINE, FISHER, MARTEN, LYNX, BOBCAT, RED FOX, AND WEASEL)

POPULATION STATUS AND TREND

Wolverines (*Gulo gulo*) are considered scarce or rare in the Greater Yellowstone Area (GYA). The GYA probably has a small population, but the actual status and range remain uncertain (Clark et al. 1989). Although the U.S. Fish and Wildlife Service has concerns about their population status as well as threats to their long-term viability, the wolverine has not been listed under the Endangered Species Act. The wolverine has been classified as a protected species in Idaho since 1965. It is a species of special concern in both Idaho (native species that are either low in numbers, limited in distribution, or have suffered significant habitat loss) and Montana (species highlighted for data acquisition and subsequent management efforts) and a Priority 3 species in Wyoming (knowledge of this species is so limited that it cannot be adequately evaluated). The wolverine is listed as a sensitive species by Region 4 (Intermountain Region) of the U.S. Forest Service and as sensitive in Idaho by Region 1 (Northern Region) (species for which population viability is a concern) (Clark et al. 1989).

Fishers (*Martes pennanti*) may exist in very low numbers within the portion of the GYA that includes the northern half of Wyoming, but they have been extirpated from the Montana portions of the GYA, and they were never known to occur in the Idaho portion of the GYA (Clark et al. 1989). The fisher is a species of special concern in Idaho and Montana and a Priority 3 species in Wyoming. Region 4 of the U.S. Forest Service lists it as a sensitive species (Clark et al. 1989).

Martens (*Martes americana*) are classified as “indicator species” on the Beaverhead, Bridger–Teton, Shoshone, and Gallatin national forests in the GYA. With appropriate management, the marten can be assured a healthy role in the GYA (Clark et al. 1989).

Specific information on the status and distribution of lynx (*Felis lynx*) in the GYA is not available. It is possible that the few reported sightings are of transient animals, but is more probable that a small population persists in the GYA (Clark et al. 1989). The lynx has been proposed for listing under the Endangered Species Act. The lynx is a species of special concern in Idaho and Montana and a Priority 3 species in Wyoming (Clark et al. 1989). Region 4 of the U.S. Forest Service lists it as a sensitive species.

The bobcat (*Felis rufus*) and red fox (*Vulpes vulpes*) are managed as furbearers in all three states and may be hunted or trapped during the furbearer season. Populations are considered stable.

The weasel (*Mustela frenata*) is an unprotected species, and little is known about its status.

LIFE HISTORY

WOLVERINE

Wolverines remain active throughout the year, even during the most severe winter weather. They inhabit the coniferous forest zone, generally at higher elevations during the summer and mid- to lower elevations during winter. Lower elevation riparian areas may be important winter habitat. Wolverines generally avoid large parks, meadows, and clearcuts. Wolverines prefer to hunt around small meadows, timbered thickets, cliffs, riparian areas, and ecotonal areas (Clark et al. 1989, USFS 1991).

Females den in late February to early March. The female may move the kits several times prior to weaning, which occurs when kits are 9–10 weeks old. The offspring normally remain near their natal area at reproductive maturation, establishing their home range near that of their mother (Copeland 1996).

Idaho wolverines denned in high-elevation, subalpine cirque basins, locating the den beneath the snow in the tunnels and chambers associated with big boulder talus. Boulder caves beneath deep snow likely provide a stable thermal environment for the protection and rearing of kits. High-elevation subalpine habitat provides seclusion and reduces vulnerability to kit predation prior to weaning. Northeasterly aspects and glacial cirques provide persistent snow coverage and den stability until the mid-May weaning period (Copeland 1996).

Fisher

Fishers prefer extensive, continuous forest canopies such as those found in dense, lowland forests or mature to old-growth spruce-fir forests with high canopy closure. They remain active throughout the year. They appear to be restricted to areas with relatively low snow accumulations, and they travel along snowshoe hare trails or their own previously made trails when snow is deep and fluffy. They avoid open areas such as meadows, grasslands, and clearcuts, and they may be limited by snow depth. Brush piles and large diameter trees, snags, and hollow logs provide critical denning sites in winter. Females usually give birth in tree dens located in high cavities of large trees. The breeding period is March through April (Clark et al. 1989, USFS 1991, Ruggiero et al. 1994, Heinemeyer and Jones 1994).

Marten

Martens remain active throughout the year. They use a variety of forest types, but they are most active in older stands of spruce-fir. In the central Rockies, they are most often associated with old-growth forests in winter. They engage in more aboreal and subnivean activity than other carnivores. They forage on mice and voles, and, as the snow deepens, they switch to pine squirrels and hares. They use meadows, forest edges, and rock alpine areas. The young are born mid-March to late April. The young are reared in dens, and the mother moves the young among dens. The dens are important to recruitment and may represent a special habitat need (Clark et al. 1989, Ruggiero et al. 1994).

Lynx

Lynx are generally found in the northern boreal forest in association with snowshoe hare habitat. Early successional forests with high densities of shrubs and seedlings are optimal habitat for hares and, consequently, important for lynx as snowshoe hares are the major food of the lynx. Hares normally make up 80 percent of the lynx diet, even more when snowshoe hare density is high. Lynx prefer dense lodgepole pine forests for hunting snowshoe hares and higher elevation spruce-fir forests for denning. Mature forest stands are used for denning and cover for kittens as well as for travel corridors. Breeding occurs from mid-March to early April. During this time females seek out males by moving into male territories (Clark et al. 1989, USFS 1991).

Bobcat, Red Fox, and Weasel

This group of carnivores remains active throughout the year. Bobcats use a wide variety of habitats. They need cover to stalk prey and avoid large open areas. Red foxes are also found in a variety of habitats, from heavily forested areas to open meadows and brushy lowlands. Red foxes mate in late winter and den in crevices, caves, or burrows. Long-tailed weasels are extremely solitary (except during the mating period) and are voracious hunters. Weasels often tunnel beneath the snow following prey when hunting during winter (Fitzgerald 1977).

HUMAN ACTIVITIES

Winter recreational activities such as snowmobiling, cross-country skiing, backcountry skiing, and snowshoeing have the potential to affect wolverine, fisher, marten, lynx, bobcat, red fox, and weasel. These mid-sized carnivores have certain biological traits that suggest vulnerability to human uses (in this case, recreational activities) specifically during the stressful winter period. These include low population densities, low reproductive rates, large home range sizes, secretive behavior, and avoidance of humans. The home range sizes of some of the mid-sized carnivores require that they regularly cross snowmobile and cross-country ski trails.

Carnivore foraging behavior in forested areas may be disrupted along groomed trails and other travel corridors. Displacement or avoidance may occur due to noise of snowmachines or to human presence. Snowmobile trails may facilitate travel for some carnivores, but compaction of snow due to grooming or from snowmobile use off existing roads or trails may adversely affect the subnivean habitat of prey species and, therefore, impact foraging opportunities for carnivores.

Existing marked and groomed snowmobile trails and the expansion of these trail systems into new areas facilitates trapping of furbearers and may increase the accidental take of non-target carnivores.

POTENTIAL EFFECTS

Forest fragmentation as a result of timber harvest is a significant source of habitat loss specifically for the fisher, marten, and lynx (Clark et al. 1989, USFS 1991, Ruggiero et al. 1994). Habitat loss could also result from clearing routes for groomed snowmobile and cross-country ski trails. However, routes in the GYA are generally along existing roads and trails, which were developed and are used for summer travel. Dispersed winter activities typically occur within non-forested areas that require no clearing.

Trapping is the most direct way that humans affect carnivore populations, and it can be a significant source of mortality. Overtrapping and accidental trapping of non-target species are considered threats to this group of animals. Highway accidents are another direct human effect on carnivores (Clark et al. 1989, USFS 1991, Ruggiero et al. 1994).

Mortality resulting from an accidental collision with a snowmobile is possible, but the probability is low. Intentional killing of carnivores by a snowmobiler is possible, but most likely it would only occur in rare, isolated incidents.

Winter stress combined with human disturbance/harassment may cause increased mortality to wildlife. Most studies on this topic have been conducted on ungulates, however. Copeland (1996) found that human activities near wolverine dens during the denning and kit-rearing period may cause den abandonment and displace wolverines into suboptimal denning sites. This could result in lower reproductive success and/or kit survival.

Natal dens are also important to recruitment for other carnivores, including the fisher, marten, and lynx. Minimal human disturbance is an important feature when females choose a den site. Fisher and lynx are likely to move to another den if disturbed.

Snowmobile use has been shown to affect snowshoe hare (an important prey species for some carnivores, particularly the lynx) and red fox mobility (Schmid 1983).

Compaction of snowfields by snowmobiles alters the mild snow microenvironment, potentially affecting organisms that live within or beneath the snow by increasing temperature stress or restricting movement by compacting the air spaces between the snow and the ground (Schmid 1983, Boyle and Sampson 1985). Winter mortality of small mammals is markedly increased under areas compacted by snowmobiles. The reduction in population numbers of these small mammals could well reduce the population of species preying upon them (Bury 1978). Fitzgerald (1977) found that the long-tailed weasel often tunnels beneath the snow when hunting during the winter. Raine (1983) found that martens made less use of subnivean space when the snow surface was crusted, probably because of difficult access.

A significant effect on carnivores from winter recreational activities is displacement from or avoidance of high recreational use areas (*i.e.*, groomed trails, marked trails, destination areas, and play areas). Human use will increase where high recreational use areas exist or are provided. As the associated recreational use level increases, the impact on carnivores also increases (Ruediger 1996).

WOLVERINE

A study in Idaho found females sensitive to human activity near the maternal den. The subalpine cirque habitats selected by Idaho wolverines for denning are often preferred winter recreational sites for backcountry skiing and snowmobiling. If females are disturbed during the denning and kit-rearing periods, they may move kits to suboptimal den sites, which may decrease reproductive success and kit survival. In two cases, human disturbance near maternal dens resulted in den abandonment by females and kits (Copeland 1996).

Humans access on snowmobiles or all-terrain vehicles in winter and early spring could cause behavioral disturbances. This disturbance may impair kit survival if females use less secure den sites (Ruggiero et al. 1994).

Other studies found that winter recreational activities affect denning. Nursery dens were abandoned by female and kits upon discovery of human tracks. Human activity around dens in Finland and Norway resulted in den abandonment (Idaho Department of Fish and Game et al. 1995).

FISHER

Fishers appear to be tolerant of moderate degrees of human activity including low-density housing, farm roads, and small-scale logging (Heinemeyer and Jones 1994). In New Hampshire, the presence of human activity and domestic animals appeared to have little effect on fisher movement (Heinemeyer and Jones 1994). Fishers in Maine tolerate a marked degree of human activity (Heinemeyer and Jones 1994). In Idaho, fishers were commonly observed in close proximity to occupied residences. They rarely flushed from their roost sites when researchers approached within a few feet. Females with kits may be more sensitive to disturbance and may move their kits periodically to new dens (Heinemeyer and Jones 1994).

Other studies show that fishers generally are more common where densities of humans are low and human disturbance is reduced. They are secretive, usually avoid humans, and seldom linger when they become aware of the presence of humans. The females use one to three dens and are more likely to move if disturbed. Indirectly, human activities may lead to negative impacts on fishers through increased human access to fisher populations (USFS 1991, Ruggiero et al. 1994, Heinemeyer and Jones 1994).

LYNX

Human access into remote areas may have direct and indirect negative effects on lynx populations. During winter and summer, lynx travel along roadways, which may make them more vulnerable to human-caused mortality (Ruggiero et al. 1994). Lynx are believed to be susceptible to human-caused disturbances during the denning period, and it is believed that females will move kittens (thereby increasing the chance for mortality) in response to disturbance. Minimal human disturbance is an important feature of the den site (Ruggiero et al. 1994, Idaho Department of Fish and Game et al. 1995).

Lynx are specialized deep-snow predators, an adaptation that permits them to live year-round at high elevations, thereby minimizing competition during the physically stressful winter months. Snowmobile or cross-country ski trails allow lynx competitors to infiltrate high-elevation habitats during winter, thereby increasing competition for a limited food supply (Idaho Department of Fish and Game et al. 1995).

The mid-sized carnivores in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

- (2) Primary transportation routes
- (3) Scenic driving routes
- (4) Groomed motorized routes
- (5) Motorized routes
- (6) Backcountry motorized areas
- (7) Groomed nonmotorized routes
- (8) Nonmotorized routes
- (9) Backcountry nonmotorized areas
- (10) Downhill sliding (nonmotorized)
- (12) Low-snow recreation areas

MANAGEMENT GUIDELINES

A literature search produced little information on how winter recreational activities impact carnivores; research on carnivores is extremely expensive and is mostly non-existent on mid-sized carnivores. Biologists, land managers, and recreation specialists will therefore need to practice “adaptive management” and “professional judgement” when developing winter use or recreational management plans until more information is available.

Existing winter trail systems/play areas and the development of new trails or designation of new play areas, particularly new areas, should be considered a negative impact on mid-sized carnivores. To avoid impacts, public land managers should exclude recreational activities from important areas that are used by carnivores during the winter.

Copeland (1996) recommends that management exclude human recreational activities within a five-mile buffer of predicted wolverine denning habitat from January 1 to May 31. Recreational activities outside the restricted time period should be managed for minimal intensity (*e.g.*, institute skier/snowmobile quotas and/or weekend closures).

Wolverines were specific in the sites they selected for natal and maternal dens in central Idaho. For example:

- Dens were situated above 8,000 feet in elevation. Although this elevational demarcation may vary throughout the wolverine’s regional distribution, it is likely applicable within the Targhee National Forest.
- Dens tended to be within a north-northeast aspect range (between compass readings greater than 320 degrees and less than 130 degrees).
- Dens selected had zero vegetative overstory (bare-exposed rock cover type).

- Den sites tended to be in the concave physiographic landscape feature of a glacial cirque.

Conserving wolverines may require large refugia connected by adequate travel corridors. Refugia provide core habitat for wolverine populations. Security areas must be available to provide undisturbed seclusion for reproducing females. Federal land-use regulations need to provide flexibility in administering backcountry winter recreational access and management (Ruggiero et al. 1994, Idaho Department of Fish and Game et al. 1995).

Providing protected areas within optimal habitat in the western mountains may be important to the persistence of lynx (Ruggiero et al. 1994). A strict, no-access management program is not recommended, but, rather, a proactive effort that involves community education and participation to protect lynx (Idaho Department of Fish and Game et al. 1995).

In many cases managers may have to use professional judgement combined with common sense to conserve the mid-sized carnivores. When conflicts occur between winter recreational activities and protection of carnivores, managers should err on the side of the carnivores. The winter period is a critical time for survival because of the extremely harsh weather conditions in the Greater Yellowstone Area.

LITERATURE CITED

Boyle, S. A., and F. B. Sampson. 1985. Effects of nonconsumptive recreation on wildlife: a review. Wildlife Society Bulletin 13:110–116.

Bury, R. L. 1978. Impacts of snowmobiles on wildlife. Pages 149–156 *in* Proceedings, 43rd North American Wildlife and Natural Resource Conference.

Clark, T. W., A. H. Harvey, R. D. Dorn, D. L. Genter, C. Groves. 1989. Rare, sensitive, and threatened species of the Greater Yellowstone Ecosystem. Northern Rockies Conservation Cooperative, Montana Natural Heritage Program, The Nature Conservancy, and Mountain West Environmental Services.

Copeland, J. P. 1996. Biology of the wolverine in central Idaho. Thesis, University of Idaho, Moscow, Idaho, USA.

Fitzgerald, B. M. 1977. Weasel predation on a cyclic population of the montane vole (*Microtus montanus*) in California. Journal of Animal Ecology 46:367–397.

Heinemeyer, K. S., and J. L. Jones. 1994. Fisher biology and management in the western United States: a literature review and adaptive management strategy. Northern Region and Interagency Forest Carnivore Working Group, U.S. Forest Service, Missoula, Montana, USA.

Idaho Department of Fish and Game, Nez Perce Tribe, and Sawtooth National Forest. 1995. Draft habitat conservation assessments and strategies for forest carnivores in Idaho.

Raine, R. M. 1983. Winter habitat use and responses to snow cover of fisher (*Martes pennanti*) and marten (*Martes americana*) in southern Manitoba. Canadian Journal of Zoology 61:25–34.

Ruediger, B. 1996. The relationship between rare carnivores and highways. Pages 24–38 *in* Proceedings of the Florida Department Transportation/Federal Highway Administration seminar on transportation-related wildlife mortality. Department of Transportation, Orlando, Florida, USA.

Ruggiero, L. F., K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski. 1994. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the western United States. General Technical Report RM-254. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Schmid, W. D. 1983. Snowmobile activity, subnivian microclimate and winter mortality of small mammals. Bulletin of the Ecological Society of America 53(2):37.

USFS (U.S. Forest Service). 1991. Threatened, endangered, and sensitive species of the Intermountain Region. Intermountain Region, Ogden, Utah, USA.

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EFFECTS OF WINTER RECREATION ON MOOSE

The distribution of moose (*Alces alces*) corresponds to environments where snow is a dominant feature in the winter. Moose are anatomically and behaviorally suited for areas where winter conditions can be harsh. These are often the same areas where humans pursue winter recreational activities. Because of this, there is a strong potential for some types of winter recreation to affect moose.

POPULATION STATUS AND TREND

Moose may have been rare in western North America during historic as well as pre-Columbian times (Peterson 1955, Kelsall and Telfer 1974, Kay 1997). However, since about 1900 moose appear to have extended their range and/or become more numerous (Kelsall and Telfer 1974, Kay 1997).

Estimating moose population size has proven to be a consistent problem in many areas (Timmermann 1974, 1993; Gasaway et al. 1986), and a lack of accurate estimates has hampered good management (Gasaway et al. 1986). Some attempts to determine moose population status and trend in the Greater Yellowstone Area (GYA) have been equally problematic (Tyers unpublished data, Gasaway 1997), and a good count for this region has not been achieved. Although demographic data are not available at a large landscape level, it is known that moose are uncommon compared to other ungulates in the GYA. In addition, populations are often at low density. In these circumstances, a conservative approach to moose population management is advised (Tyers unpublished data, Gasaway 1997, Karns 1997).

Some information on moose populations in the GYA is available. Houston (1982) reported that moose remains have not been found in archeological sites in northwest Wyoming or south central Montana. He concluded that moose had not yet occupied northwest Wyoming in 1830 (Houston 1968), but had colonized the Yellowstone area by the 1870s; they appeared on Yellowstone's northern range around 1913 (Houston 1982). Schullery and Whittlesey (1992) reviewed the documentary record for wolves and related wildlife species in the Yellowstone National Park area prior to 1882. Based on historic accounts, they concluded that moose were common in the southern part of the park in 1882, and rare sightings were made near or on the northern range about the same time.

Recent studies indicate a population decline following the 1988 Yellowstone fires in areas where fire effects were severe and in areas where moose rely on older lodgepole pine forests for winter range (Tyers unpublished data, Tyers and Irby 1995). In response to these data, Montana Fish, Wildlife and Parks has significantly reduced hunting quotas in districts north of Yellowstone National Park (T. Lemke, Montana Fish, Wildlife and Parks, personal communication). In portions of the GYA where moose have different winter-use patterns or where fire effects are not an issue, the trend may be different.

Several hypotheses have been proposed to explain the biogeography of moose in western North America. Kelsall and Telfer (1974) presented five hypotheses to explain the relatively recent expansion of moose. These include: (1) moose have had a limited amount of time to colonize North America since the last glaciation; (2) climatic variation—the Little Ice Age and associated severe winter weather limited moose populations around

1700–1800; (3) disease once limited moose numbers; (4) European settlement modified the original climax forests, which were poor moose habitat, and created seral vegetation types that moose prefer; and (5) predators once limited moose, but the near extermination of native carnivores allowed moose to extend their range and expand their populations.

Kay (1997) proposed a sixth hypothesis: moose were extremely vulnerable to predation by Native Americans who had no effective conservation practices. The result was a control of moose biogeography by native hunting.

Loope and Gruell (1973) proposed a seventh hypothesis specific to the GYA: a very low moose population during the 19th century was the result of fires, which maintained early successional vegetation. They speculated that moose populations have increased in this century in northwest Wyoming as forests have matured under a management policy of fire suppression. A primary factor in this, they believe, is an increase in subalpine fir, a shade-tolerant species found in older forests. They further hypothesized that subalpine fir is the staple food item in the diets of moose in the area. Tyers (unpublished data) tested this hypothesis and demonstrated that moose along the northern border of Yellowstone National Park feed primarily on subalpine fir saplings in older lodgepole forests.

Although the Shiras moose is a relatively recent arrival to the GYA, available habitat is now occupied. However, future population trends are uncertain. Habitat conditions, human influences, and exposure to predation vary considerably across the GYA. In addition, the small home range size of moose and the strong fidelity moose show to a geographic area tend to create many fairly discrete populations. For these reasons, it is likely that local populations will display very different trends.

As evidenced by the hypotheses for recent moose range expansion explained above, future trends in the GYA will be largely determined by predation and habitat quality. Humans, bears, and wolves prey upon moose in the GYA. The recent reintroduction of wolves is an important variable with unknown consequences. Some have speculated that wolves will play a major role in regulating moose populations, and a decrease in moose numbers will be noticed (Messier et al. 1995). The 1988 Yellowstone fires were a landscape-level disturbance that affected the successional stage of vegetation. This will undoubtedly be a determining factor for moose populations in a large spatial and temporal context. In many parts of the GYA, a return to an early successional stage represents a decrease in moose winter habitat that will reduce carrying capacity (Tyers unpublished data). Riparian areas with deciduous vegetation are important foraging areas for moose. They are limited in size and distribution and are particularly vulnerable to human impacts. Management of these areas will also play a role in determining moose population trends.

Life History

Moose are seasonal breeders with the mating season in the fall and calving in the spring. Most cows ovulate for the first time between 16 to 28 months of age, although those in populations on poor range may not breed until 40 months. Most cow moose produce either single or twin calves. Twinning varies widely across North America and may be correlated to habitat quality and carrying capacity. Triplets have been reported but are rare. Most cows produce a calf or calves each year. Neonatal predation is common and can be high (Schwartz 1997). Average life span is highly variable; generally, it may be 7 or 8 years with a maximum age at possibly 20 (Ballard and Van Ballenberg 1997).

HABITAT

As a generalization, the moose is an animal of the boreal forests—the coniferous forests that occur in a broad band across northern North America and Eurasia. Boreal forests also extend southward at higher elevations in the mountains. The climate within this biome is characterized by cold winters and short, mild summers (Brewer 1994). Food and cover are the primary factors limiting geographic distribution in the north (Kelsall and Telfer 1974), and climate is the factor in the south (Reneker and Hudson 1986). The most critical factor, especially to the southern distribution of moose, is temperature (heat) (Karns 1997).

Moose are browsers—herbivores that eat primarily shrubs and trees (Peterson 1955, Renecker and Schwartz 1997). Specifically, they eat twigs and foliage high in cell-soluble sugars that ferment readily in the rumen. These are foods that are considered to be, comparatively, of poor quality. In addition, they are characterized as concentrate selectors. Because of their body size, they require large amounts of abundant food to survive. To satisfy this need, they seek out concentrations or patches of biomass in the environment where they can spend relatively long periods of time foraging. For example, moose seek out or select willow (*Salix* spp.) that often offers large amounts of forage bunched together on the landscape. Because of their dietary constraints, the quantity of biomass for foraging determines moose density.

The large body size of moose is an advantage in boreal regions for coping with predators and periods of extreme cold and deep snow (Renecker and Hudson 1986, 1989). However, it also imposes limitations on activities. Moose have a difficult time dissipating heat, and heat stress can lead to a reduction in overall activity during warm periods. Ambient air temperatures above 23° Fahrenheit in winter and above 57° Fahrenheit in summer can be stressful and can cause moose to seek cooler areas. In a broader sense, problems with thermal regulation restrict range expansion into more temperate climates.

Telfer (1984) placed moose habitat in six broad categories: boreal forests, mixed forest, large delta floodplains, tundra, subalpine shrub, and stream valleys. These may be further described as either permanent or transitory in nature (Geist 1971, Peek 1997). Permanent habitats are those that persist and do not succeed over time to a different pattern of vegetation. For example, alluvial habitats are dynamic in that flooding and streambed alteration produce a constantly changing system, but they are permanent in the sense that the same type of vegetation is present after a disturbance. Boreal forests are more transitory. Fire can radically alter the vegetative composition; a mature forest can be changed to a shrub community. The shrub community will eventually be dominated by a forest that is vulnerable to a fire event just as the first one was. The pattern is cyclic, and each successional stage is transitory to the next.

Throughout much of their range, moose are found in transitory habitats. Specifically, they are closely linked to early seral stages where shrub biomass is plentiful (Dryness 1973, Wittinger et al. 1977, Irwin and Peek 1979). In many areas, moose benefit from the removal of the forest canopy (Taber 1966, Krefting 1974, Kelsall and Telfer 1974, Leresche et al. 1974, Irwin 1975, Peek et al. 1976). Disturbances such as fire, logging (or other forms of mechanical manipulation), disease, or wind events can create favorable moose habitat by removing trees that compete for resources with shrubs.

However, it is also known that moose winter habitat-use patterns can be highly variable between regions and years (Peek 1974a), which reflects adaptive responses to different environmental conditions. Peek (1974a) cautioned against making unequivocal generalizations about moose winter habitat selection and suggested that the amount of variability can make these descriptions misleading. Included are statements about the role of transitory habitats, forest canopies, and seral stages in moose habitat. He stated that this variability has special consequences to management because it is important to determine the forage species locally preferred by moose and then favor those species through management actions.

Snow conditions have an important influence on moose habitat-use patterns (Peek 1997). Conditions include temperature, density, hardness, and depth (Peek 1997), and factors that affect the ability of moose to access browse (Peek 1971, Schladweiler 1973). The presence or absence of a forest canopy can have a significant effect on snow conditions. For example, moose often prefer open brush fields for foraging where browse is abundant. They have also been known to seek coniferous forests when snow conditions impeded movements in open areas (des Mueles 1964, Kelsall 1969, Telfer 1984, Peek et al. 1976, Rolley and Keith 1980, Thompson and Vukelich 1981). Travel in forests is often less energy demanding because tree branches ameliorate snow density, hardness, and depth through shading and intercepting falling snow.

Several studies have reported specific snow depth thresholds for moose. Snow depths of 25.5 inches have been reported to affect habitat use and movements of moose (Kelsall 1969, Thompson and Vukelich 1981, Pierce and Peek 1984). In Quebec, des Mueles (1964) found that moose shifted to more dense coniferous areas when snow depth reached 30 to 34 inches, and moose did not use areas where the snow exceeded 42 to 48 inches, even when the snow was soft. Kelsall (1969) reported moose were severely restricted by snow depths of 27.5 to 35.5 inches. Kelsall and Prescott (1971) found that when snow depths reached 38 inches in New Brunswick moose where confined to areas with high forest canopies. Tyers (unpublished data) demonstrated that moose on Yellowstone's northern range avoided snow depths greater than 31.5 to 43 inches and were not found when snow exceeded 54.5 inches.

Peek (1974a) reported on the variability in the winter habitat used by moose in North America. He reviewed 41 different reports: 13 from the Intermountain West; 6 from Alaska; and 22 from Canada, Minnesota, and Maine. His review highlighted the variation and commonality in the diet and forest successional stage used by moose. In another document (1974b) he focused on the Shiras moose. He identified five different types of winter habitat for the Shiras moose in the Intermountain West, an area that includes the GYA:

1. Willow bottom/stream/conifer complex occurring along high-gradient streams.
2. Flood plain riparian community containing extensive willow stands.
3. Drainages where willow-bottom communities are very limited and are of little importance to moose, but where conifer and aspen types are important, and the diet is more varied than in areas where willow is plentiful.
4. Arid juniper hills.
5. Willow communities that are important but are neither limited nor extensive. Moose are forced from these areas by snow conditions into adjacent forested slopes where subalpine fir stands support low-density moose populations in winter.

Studies conducted in the GYA portion of the Intermountain West accent the variability of moose habitat use. The results generally fit into one of Peek's (1974b) five categories, but there are important differences in habitat use by moose in this area and the moose of other areas. For example, McDowell and Moy (1942) did a descriptive study of moose habitat use in the Hellroaring/Slough Creek area north of Yellowstone National Park (Peek's Type 5). They noticed an early winter association of moose and the limited willow areas, and then a move to adjacent conifer types, presumably in response to increasing snow depths. Harry (1957) and Houston (1968) documented use by moose of the extensive willow areas on the flood plains of Jackson Hole, Wyoming (Peek's Type 2). Stevens (1970) found Douglas fir and aspen communities to be the key winter range in the Gallatin Mountains (Peek's Type 3). Tyers (unpublished data, Tyers and Irby 1995) investigated moose habitat use on Yellowstone's northern range and documented moose using older lodgepole pine forests during the most difficult winter months where they browsed almost exclusively on subalpine fir saplings and seedlings (Peek's Type 5).

HUMAN ACTIVITIES

There are few examples in the literature that describe the effect of various types of human activity on wintering moose. Although several studies address changes in movements and habitat use, none appear to demonstrate resulting demographic changes.

Moose are thought to be comparatively tolerant of humans and to have the ability to develop a high level of habituation (Shank 1979). This is illustrated in several ways, including flight distance. Moose unaccustomed to humans usually run about 150 yards, but habituated individuals may allow approaches to within 20 to 25 yards (Shank 1979). As a further example, Westworth et al. (1989) found that moose in British Columbia were able to habituate to disturbances associated with surface mining, including vehicular traffic, plant machinery, and blasting of ore reserves. Pellet group densities, used as an index of moose abundance, were highest on a transect 100 yards from the open pit. This transect had a particularly high density of browse leading the authors to concluded that moose distribution was influenced more by browse availability among different habitat types than by disturbance associated with mining. Pellet groups also demonstrated moose activity as close as 15 yards from the pit at sites where browse was present.

The response of moose to the mine in British Columbia (Westworth et al. 1989) and similar situations may be explained by a theory proposed by Geist (1971). He stated that if visual and acoustical stimuli are predictable in space and time, the process of habituation by wildlife is enhanced. Mine activity and some forms of winter recreation can be predictable. In contrast, panic responses may occur as a result of any kind of abrupt unexpected intrusion (Busnel 1978).

Westworth et al. (1989) proposed that the mine was actually an asset to moose. Moose in the area are exposed to predation by wolves. The mining activity displaced wolves, offering security to moose not available away from the mine site.

Rudd and Irwin (1985) investigated impacts to wintering moose resulting from oil and gas extraction and recreational activities in western Wyoming. The number of shrub species available in proximity to a plowed road was the best predictor of moose presence or absence. Relative to people on snowshoes, skis, or snowmobiles, trucks associated with resource extraction caused the greatest disturbance to moose. People on snowshoes or skis caused more disturbances than snowmobiles. The average distance 18 moose ran to escape trucks was 16.9 yards, and the average distance at which moose where displaced was 169 yards; 21 percent were displaced, and 48 percent showed some type of disturbance behavior. The average distance 19 moose moved away from people on snowshoes or skis was 16.6 yards, and the average distance at which moose were displaced was 80.7 yards; 17 of the 19 moose moved to a different location, and all showed signs of disturbance. The average distance 242 moose ran to escape a snowmobile was 10.5 yards, and the average distance at which moose were displaced by snowmobiles was 59.25 yards; 50 percent of the encounters between moose and snowmobiles resulted in displacement while 94 percent showed some form of disturbance. Rudd and Irwin (1985) recommended that winter recreational use and mine activity be restricted near preferred moose winter range.

Ferguson and Keith (1983) addressed the influence of nordic skiing on moose and elk in Elk Island National Park, Alberta. They found that cross-country skiing influenced the general over-winter distribution of moose. Moose tended to move away from areas near heavily used trails more than lightly used trails during the ski season (January through March). Daily movements away from trails occurred after the onset of skiing. However, once displacement occurred, additional skiers did not generate a greater displacement.

The flight behavior of moose is unusual and often misinterpreted. Their reputation of being tolerant to humans may in part be because their stress response is more subtle than that of other ungulates. Shank (1979) reported a common response of moose to a disturbance was that they rarely reacted immediately and overtly to disturbing stimuli unless that stimulus was very intense. Often, they continued feeding and might even increase the intensity of feeding. While this is occurring, they moved without obvious sign of stress toward cover. Once cover was reached, they usually looked directly at the source of the disturbance, often for the first time, and then ran. Until the moose bolts, stress may not be obvious because it is expressed in less noticeable physiological responses, such as increased breathing and elimination rates.

Reports dealing specifically with collisions between wintering moose and vehicles and trains are more common. Examples can be found from most areas with important moose populations. Because winter recreation frequently involves plowing roads and accessing recreation areas with motorized conveyance, the topic is relevant.

Lavsund and Sandegren (1991) reviewed moose/vehicle relations in Sweden and described the situation as a serious problem both in terms of human safety and mortality of moose. Risk was highest at dawn and dusk and higher at night than during the daytime. In southern Sweden where winter snow accumulation is less important, collisions peak in early summer during calving and in autumn during the rut. In northern Sweden, collisions peak during December and January when snows initiate moose migrations to lowland ranges where major roads are common. Various methods were tried to reduce the number of moose/vehicle collisions. Repellants in the form of flashing lights, sounds, and scents were not effective. The results of roadside clearing to improve visibility for drivers demonstrated a reduction that was no better than what might have been arrived at by chance. Efforts to educate drivers on how to scan the roadside and anticipate risks did not seem to change driver behavior—good drivers were cautious, and bad drivers remained incautious. Neither road authorities nor drivers were interested in reducing the speed limit. Fencing the roads was effective at reducing collisions by 80 percent.

In Alaska, measures were taken to mitigate moose/vehicle collisions along a stretch of highway that was improved (Child et al. 1991). A moose-proof fence, moose underpass, and highway lighting all were effective at significantly reducing collisions. Collisions were reduced 95 percent in the fenced portion of the highway when compared to the previous decade before the highway was improved and mitigation measures were put in place. The reduction in loss of moose allowed an increase in hunter harvest. Child et al. (1991) estimated that approximately 10 percent of the annual allowable harvest in the province of British Columbia die as a result of collisions on highways and railways. The impact of this on the demographics of the moose population is unknown.

Collisions between moose and motorists on the Kenai Peninsula, Alaska, were also reported to be a severe problem (Del Frate and Sparker 1991). The number of road-killed moose nearly doubled following the new policy of the Department of Transportation to improve snow-clearing efforts. Better road conditions allowed motorists to travel faster. Collisions also increased during a severe winter when moose sought relief from harsh snow conditions by attempting to winter close to plowed roads. In response, a public awareness program was started using roadside signs, bumper stickers, and programs in schools. The number of moose mortalities declined 18 percent the following year, but the authors were not confident the education program was responsible. The results were confounded by mild winter conditions that allowed moose to winter farther from the roads. As mitigation, they called for avoiding building roads in moose winter range, brushing roadsides to increase visibility, and fencing.

Rudd and Irwin (1985) found that site features had some effect on how moose tried to escape humans. When exiting roads freely, moose selected areas with less steep slopes than random samples, especially slopes of less than 5 percent. In 83 percent of the cases, moose exited at points where snow depth along the road was less than the average depth, although this difference was not statistically significant. During forced exits, moose chose slopes in proportion to what was available. The average snow depth of the berm was significantly greater along the road than where moose exited under duress. The average canopy closure was significantly greater at these exit spots than in random samples.

Bubenik (1997) reported that mature, healthy moose stand their ground when confronted by wolves, and inexperienced moose generally run and are killed. Child et al. (1991) and Bubenik (1997) saw a connection between this and the high incidence of collisions with trains. Moose use the same survival strategy during confrontations with trains as they do with wolves. With trains this tactic is fatal. The problem is exacerbated by the effect of headlights, which hypnotize moose and interfere with avoidance movements.

Anderson et al. (1991) determined that snow conditions greatly influenced annual variation in moose killed by trains in Norway. Mean annual snow depth was able to explain 84 percent of the annual variation in train kills. They believed three factors were responsible for this close correlation. First, early snows seemed to increase the speed, timing, and magnitude of moose movements to winter range. This places them on train tracks earlier in the season. Secondly, although moose are morphologically adapted for survival in snow, snow depths of greater that 39 inches seemed to motivate moose to seek the plowed railroad beds for movements between feeding sites.

Third, as snow depths increased moose were less successful at escaping the tracks in the face of oncoming trains. Because of snow conditions they returned to solid ground on the tracks and tried to outdistance the approaching train instead of climbing over the snow berm. In addition, more collisions occurred after dark when moose were more active; they became hypnotized by train lights and train personnel had greater difficulty observing moose. They also found temperatures below 20° C tended to increase the risk of collision, while temperatures above 0° C had the opposite effect. The authors speculated this occurred because moose are foraging more actively at lower temperatures.

Becker and Grauvogel (1991) investigated moose/train collisions in Alaska. They observed that most moose that were struck were using the tracks as a travel corridor in a winter environment. Most had time to exit the tracks but, instead, usually tried to outrun the train. Snow depths were around 35.5 inches, and moose that did leave the tracks floundered and returned to the tracks, which probably increased their sense of vulnerability to a perceived predator, the train. They experimented with decreasing the average speed of the trains (from 48 to 25 miles per hour) to see if moose mortalities could be reduced. The reasoning was that at a reduced speed there would be more reaction time for train personnel and more time for moose to escape. The reduction did not reduce the number of moose mortalities, and the train company determined that, based on economics, they could not afford to reduce the train's speed below 25 miles per hour. The authors believed that a threshold did exist below which a positive response would occur, but it appears to be below 25 miles per hour, which is not economically practical for the train company.

Modafferi (1991) also investigated the relationships between moose/train collisions, snowpack depth, and moose distribution. The setting was the lower Sustina Valley in Alaska. More than 73 percent of mortalities occurred from January through March. Mortality was greatest along stretches of railway that passed through moose winter range. As snow depth increased, mortalities increased.

Potential Effects

The literature indicates moose can be impacted by human activities in the winter. However, moose habitat requirements are specific, and their use of selected areas is traditional. The presence or absence of moose winter activity is easy to verify through tracks, pellet groups, beds, sightings, and evidence of browsing. Investigations in summer or winter will demonstrate whether or not moose are using the area as winter range. As discussed, the specific attributes of moose winter range are variable. However, in all cases a winter range will include a concentration of accessible browse material such as deciduous trees and shrubs, especially willow and aspen. In some cases, browse may be subalpine fir saplings. Cover, in the form of dense coniferous forests, may also be present. Some of the best moose winter range is found where browse concentrations are in juxtaposition with cover. If snow conditions preclude access to the browse, moose will not be present.

Impacts of recreational use may take several forms. Moose may be negatively impacted by a loss of winter habitat if construction of facilities removes habitat features resulting in a loss of foraging opportunities or cover. Negative impacts may also occur if moose are subject to displacement that results in a drain on energy reserves. Because they are often in an environment where snow is deep, flight can be energetically costly. The literature indicates flight and stress are most likely when the source of the disturbance is unpredictable, is severe to sensory perception, and is in close proximity. There is also the possibility that if disturbances are not of this nature, moose may habituate to human activities and show high tolerance. Moose may even seek centers of human activity as security from predators.

Moose are also uniquely vulnerable to mortality by collisions with vehicles. This is because of the relationship between moose, browse availability, and snow conditions. Plowed roads or train tracks in moose winter range offer moose relief from snow conditions as well as travel corridors to sources of browse. This, combined with their instinctive response of standing their ground in the face of a perceived threat help explain why this is such a serious problem in many areas. Winters with above average snow depths exacerbate the problem.

Moose in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(1) Destination areas. Human activity at destination areas has the potential to negatively impact moose. Habitat can be lost if facilities are built in moose winter range. Individual animals can be affected if a flight response is initiated through contact with humans or their dogs. If human activities are predictable, moose may become habituated. If predation is intense, moose may even seek the site as a refuge.

(2) Primary transportation routes and (3) scenic driving routes. Human activity along driving routes has the potential to negatively impact moose. Habitat can be lost through road construction. Individual animals can be affected by collisions with vehicles or by energetically expensive flight responses.

(4) Groomed motorized routes and (5) motorized routes. Individual animals may be affected if a flight response is initiated by contact with vehicles. Moose may use the groomed surface as a travel route and invite collisions with oversnow vehicles. If human activities are predictable, moose may become habituated.

(6) Backcountry motorized areas. Because of the way humans recreate in these areas, it is unlikely their activities will be predictable to moose. Routes, time of day, and numbers of people will be highly variable. As a result, there is a high probability of initiating a flight response and a low probability of habituation occurring. In addition, there is a chance snowmobilers will approach or even chase moose because their movements are unrestricted. This could be energetically very expensive for moose.

(7) Groomed nonmotorized routes and (8) nonmotorized routes. Human activity may initiate energetically expensive flight responses. If human activity is predictable, some level of habituation may occur. Because established routes will be used, the chance that habituation will occur is enhanced. Moose may use groomed routes as travel corridors making encounters with people more likely. However, because the activity will not be motorized and grooming vehicles move slowly, collision is not a risk.

(9) Backcountry nonmotorized areas. Because of the way humans use these areas, it is unlikely their activities will be predictable to moose. As a result, there is a high probability of initiating flight response and a low probability of habituation occurring.

In addition, there is a chance that skiers will approach moose because their movements are unrestricted, which could be energetically expensive to moose. However, it is less likely skiers will actually chase moose.

(10) Downhill sliding (nonmotorized). These areas are usually limited in size. Unless they are located in especially productive moose winter range, impacts should be minimal.

(12) Low-snow recreational areas. Moose winter range is usually at higher elevation where snow accumulation is comparatively greater. More xeric habitats do not provide moose forage. A possible exception is riparian areas at low elevation that may be used by moose as winter range. In these instances, moose could be impacted by a loss of habitat or by displacement. However, flight responses would not be as energetically expensive as it would be in locations where snow conditions are deeper.

MANAGEMENT GUIDELINES

- Avoid building winter recreational facilities in moose winter range. This will prevent a loss of habitat and reduce encounters that elicit energetically expensive flight responses. As stated, moose winter range is not difficult to identify. All components of the wintering area should be considered, including foraging areas, cover, and travel corridors.
- Where human use does occur in moose winter range, regulate activities to make them as predictable as possible. This can be accomplished by restricting them spatially and temporally. For example, restrict skiing or snowmobiling to designated paths and to daylight hours.
- Where plowed roads exist in moose winter range, reduce the risk of collisions by plowing escape corridors in roadside snow berms, reducing speed limits, alerting motorists to the risk by signing and other educational efforts, providing roadside lighting, restricting travel to daylight hours, fencing road corridors, providing underpasses for moose to cross the road, and removing roadside barriers that limit visibility.
- Educate the public so that they can take appropriate measures to avoid impacting moose. They should understand the impacts of chasing or approaching moose and the importance of controlling the movement of dogs.
- A monitoring program should be established to follow moose population trends and assess potential conflicts with moose. A variety of methods are available with which to develop either an index with comparatively little investment or to conduct a more intense survey (Tyers unpublished data; Timmermann 1974, 1993; Gasaway 1997).

LITERATURE CITED

Anderson, R., B. Wiseth, P. H. Pedersen, and V. Jaren. 1991. Moose-train collisions: effects of environmental conditions. Alces 27:79–84.

Ballard, W. B., and V. Van Ballenberg. 1997. Population dynamics. Pages 223–246 *in* A. W. Franzmann and C. C. Schwartz, editors. Ecology and management of the North American moose. Smithsonian Institution Press, Washington, D.C., USA, and London, England.

Becker E. F., and C. A. Grauvogel. 1991. Relationship of reduced train speed on moose-train collisions in Alaska. Alces 27:161–168.

Brewer, R. 1994. The science of ecology. Second edition. Saunders College, Harcourt Brace, Fort Worth, Texas, USA.

Bubenik, A. B. 1997. Evolution, taxonomy and morphology. Pages 77–174 *in* A. W. Franzmann and C. C. Schwartz, editors. Ecology and management of the North American moose. Smithsonian Institution Press, Washington, D.C., USA, and London, England.

Busnel, R. G. 1978. Introduction *in* J. L. Fletcher and R. G. Busnel, editors. Effects of noise on wildlife. Academic Press, New York, New York, USA.

Child, K. N., S. P. Barry, and D. A. Aitken. 1991. Moose mortality on highways and railways in British Columbia. Alces 27:41–49.

Del Frate, G. G., and T. H. Sparker. 1991. Moose vehicle interactions and an associated public awareness program on the Kenai Peninsula, Alaska. Alces 27:1–7.

des Mueles, P. 1964. The influence of snow on the behavior of moose. Transactions North American Wildlife Conference 21.

Dryness, C. T. 1973. Early stages of plant succession following logging and burning in the western Cascades of Oregon. Ecology 54:57–69.

Ferguson, M. A. D., and L. B. Keith. 1983. Influence of nordic skiing on distribution of moose and elk in Elk Island National Park, Alberta. Canadian Field Naturalist 96(1):69–78.

Gasaway, W. C. 1997. Monitoring moose population status in the northern range of Yellowstone National Park and adjacent lands: an assessment of methods. U.S. Forest Service, Gallatin National Forest, Gardiner, Montana, USA.

———, S. D. Dubois, D. J. Reed, and S. J. Harbo. 1986. Estimating moose populations' parameters from aerial surveys. Biological papers of the University of Alaska, No. 22.

Geist, V. 1971. A behavioral approach to the management of wild ungulates. Pages 413–424 *in* E. Duffey and A. S. Watt, editors. The scientific management of animal and plant communities for conservation. Eleventh Symposium of the British Ecological Society.

Harry, G. B. 1957. Winter food habits of moose in Jackson Hole Wyoming. Journal of Wildlife Management 21:53–57.

Houston, D. B. 1968. The Shiras moose in Jackson Hole, Wyoming. Grand Teton Natural History Association Technical Bulletin Number 1.

———. 1982. The northern Yellowstone elk: ecology and management. McMillian, New York, New York, USA.

Irwin, L. L. 1975. Deer-moose relationships on a burn in northeastern Minnesota. Journal of Wildlife Management 39:653–662.

———, and J. M. Peek. 1979. Shrub production and biomass trends following five logging treatments within the cedar-hemlock zone of northern Idaho. Forest Science 25:415–426.

Karns, P. D. 1997. Population distribution, density, and trends. Pages 125–140 *in* A. W. Franzmann and C. C. Schwartz, editors. Ecology and management of the North American moose. Smithsonian Institution Press, Washington, D.C., USA, and London, England.

Kay, C. E. 1997. Aboriginal overkill and the biogeography of moose in western North America. Alces 33:141–164.

Kelsall, J. P. 1969. Structural adaptations of moose and deer for snow. Journal of Mammalogy 50(2):302–310.

———, and W. Prescott. 1971. Moose and deer behavior in snow. Report Series 15. Canadian Wildlife Resources (Supplement)1:1–10.

Kelsall, J. P., and E. S. Telfer. 1974. Biogeography of moose with particular reference to western North America. Le Naturaliste Canadien 101:117–130.

Krefting, L. W. 1974. Moose distribution and habitat selection in north central North America. Le Naturaliste Canadien 101:81–100.

Lavsund, S., and F. Snadgren. 1991. Moose-vehicle relations in Sweden: a review. Alces 27:118–126.

Leresche, R. E., R. H. Bishop, and J. W. Coady. 1974. Distribution and habitat of moose in Alaska. Le Naturaliste Canadien 101:143–178.

Loope, L. L., and G. Gruell. 1973. The ecological role of fire in the Jackson Hole area, northwestern Wyoming. Quaternary Research 3, 425–443.

McDowell, L., and M. Moy. 1942. Montana moose survey, Hellroaring-Buffalo Fork-Slough Creek unit. Unpublished report. Montana Department of Fish and Game.

Messier, F., W. C. Gasaway, and R. O. Peterson. 1995. Wolf-ungulate interactions in the northern range of Yellowstone: hypotheses, research priorities, and methodologies. Submitted to U.S. Department of Interior, National Biological Service, mid-Continental Ecological Science Center.

Modafferi, R. D. 1991. Train moose-kill in Alaska: characteristics and relationship with snowpack depth and moose distribution in lower Susitna Valley. Alces 27:193–207.

Peek, J. M. 1971. Moose-snow relationships in northeastern Minnesota. Pages 39–49 *in* A. O. Haugen, editor. Proceedings of symposium on snow and ice in relation to wildlife and recreation. Iowa State University, Ames, Iowa, USA.

———. 1974a. A review of food habit studies in North America. Le Naturaliste Canadien 101:195–215.

———. 1974b. On the nature of winter habits of Shiras moose. Le Naturaliste Canadien 101:131–174.

———. 1997. Habitat relationships. Pages 351–376 *in* A. W. Franzmann and C. C. Schwartz, editors. Ecology and management of the North American moose. Smithsonian Institution Press, Washington, D.C., USA, and London, England.

———, D. L. Urich, and R. J. Mackie. 1976. Moose habitat selection and relationships to forest management in northeastern Minnesota. Wildlife Monograph Number 48.

Peterson, R. L. 1955. North American moose. University of Toronto Press, Toronto, Ontario, Canada.

Pierce, J. D., and J. M. Peek. 1984. Moose habitat use and selection patterns in north central Idaho. Journal of Wildlife Management 48:1335–1343.

Reneker, L. A., and R. J. Hudson. 1986. Seasonal energy expenditure and thermoregulatory response of moose. Canadian Journal of Zoology 64:322–327.

———, and ———. 1989. Ecological metabolism of moose in aspen-dominated boreal forests, central Alberta. Canadian Journal of Zoology 67:1923–1928.

Reneker, L. A., and C. C. Schwartz. 1997. Food habits and feeding behavior. Pages 403–440 *in* A. W. Franzmann and C. C. Schwartz, editors. Ecology and management of the North American moose. Smithsonian Institution Press, Washington, D.C., USA, and London, England.

Rolley, R. E., and L. B. Keith. 1980. Moose population dynamics and winter habitat use at Rochester, Alberta, 1965–1979. Canadian Field Naturalist 94:9–18.

Rudd, L. T., and L. L. Irwin. 1985. Wintering moose vs. oil/gas activity in western Wyoming. Alces 21:279–298.

Schldweiler, P. 1973. Ecology of Shiras moose in Montana. Big game research projects W-98-R and W-120-R, final report. Montana Department of Fish and Game.

Schullery, P., and L. Whittlesey. 1992. The documentary record of wolves and related wildlife species in the Yellowstone National Park area prior to 1882. Pages 1–3 and 1–73 *in* J. D. Varley and W. G. Brewster, editors. Wolves for Yellowstone? A report to the United States Congress, Volume 4, research and analysis. National Park Service, Yellowstone National Park, Wyoming, USA.

Schwartz C. C. 1997. Reproduction, natality, and growth. Pages 141–172 *in* A. W. Franzmann and C. C. Schwartz, editors. Ecology and management of the North American moose. Smithsonian Institution Press, Washington, D.C., USA, and London, England.

Shank, C. C. 1979. Human related behavioral disturbance to northern large mammals: a bibliography and review. Report prepared for Foothills Pipe Lines (South Yukon) Limited, Calgary, Canada.

Stevens, D. R. 1970. Winter ecology of moose in the Gallatin Mountains, Montana. Journal of Wildlife Management 34(1):37–46.

Taber, R. D. 1966. Land use and native cervid populations in America north of Mexico. Transactions of the Congress International Union of Game Biologists 6:201–225.

Telfer, E. S. 1984. Circumpolar distribution and habitat requirements of moose (*Alces alces*). Pages 145–182 *in* R. Olson, R. Hastings, and F. Geddes, editors. Northern ecology and resource management. University of Alberta Press, Edmonton, Canada.

Thompson, I. D., and M. F. Vukelich. 1981. Use of logged habitats in winter by moose cows with calves in northeastern Ontario. Canadian Journal of Zoology 59:2103–2114.

Timmermann, H. R. 1974. Moose inventory methods: a review. Le Naturaliste Canadien 101:615–629.

———. 1993. Use of aerial surveys for estimating and monitoring moose populations: a review. Alces 29:35–46.

Tyers, D. B. Unpublished data. U.S. Forest Service, Gallatin National Forest, Gardiner, Montana, USA.

———, and L. R. Irby. 1995. Shiras moose winter habitat use in the upper Yellowstone River valley prior to and after the 1988 fires. Alces 31:35–43.

Westworth, D., L. Brusnyk, J. Roberts, and H. Veldhuzien. 1989. Winter habitat use by moose in the vicinity of an open pit copper mine in north-central British Columbia. Alces 25:156–166.

Wittinger, W. T., W. L. Pengelly, L. L. Irwin, and J. M. Peek. 1977. A 20-year record of shrub succession in logged areas in the cedar-hemlock zone of northern Idaho. Northwest Science 51:161–171.

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EFFECTS OF WINTER RECREATION ON MOUNTAIN GOATS

POPULATION STATUS AND TREND

Mountain goats (*Oreamnos americanus*) were historically distributed in North America in the western coastal ranges from Alaska to northern Washington and in the Rocky Mountains from northern Canada to northern Montana and central Idaho. Through introductions, primarily by state wildlife agencies, their distribution has been successfully expanded into vacant habitats in their historic range, as well as in habitat outside their historic range in the western United States (Johnson 1977, Wigal and Coggins 1982). Mountain goats were introduced into the Greater Yellowstone Area (GYA) by state fish and game agencies in Montana and Idaho for recreational purposes, including hunting (Brandborg 1955, Montana Department of Fish and Game 1976, Hayden 1984, Swenson 1985, Laundre 1990, Varley 1995). Most introductions took place between 1940 and 1960 and were successful in achieving self-sustaining populations. Many of the founder herds were productive and colonized unoccupied areas, including mountain ranges that did not receive transplants, such as the Gallatin Mountains. Currently mountain goats inhabit most mountain ranges with appreciable alpine habitat in the GYA (see Table 2). The population trend for goats in these areas is generally stable or growing (Swenson 1985, Laundre 1990, Lemke 1996), and most herds sustain a conservative annual harvest.

LIFE HISTORY

Mountain goats are social animals generally found in small groups (Brandborg 1955, Chadwick 1977), though single individuals are commonly encountered. During most of the year, adult males generally avoid adult females except where centralized resources, such as mineral licks, bring them together. Males court females during the breeding season in November and early December then leave the female group sometime during the winter (Brandborg 1955, Chadwick 1973, Smith 1977, Wigal and Coggins 1982).

Mountain goat populations are generally considered to be slow growing and have low productivity (Eastman 1977, Stevens 1983, Chadwick 1983). Goats become sexually mature at the age of 2.5 (these goats give birth

Table 2. Mountain ranges in which goats are found in the Greater Yellowstone Area

Mountain Range	Population[1]	State	References[2]
Absaroka Range	360–490	MT, WY	Swenson 1985, Varley 1995
Beartooth Mountains	365–425	MT, WY	Haynes 1992
Bridger Range	85–90	MT	
Centennial Mountains	No estimate	ID, MT	
Crazy Mountains	175–200	MT	Lentfer 1955, Saunders 1955, Foss 1962
Gallatin Mountains	50–60	MT, WY	
Gravelly Range	No estimate	MT	
Madison Range	No estimate	MT	Peck 1972
Palisade Range	128–142	ID, WY	Hayden 1984, 1989
Tobacco Roots	No estimate	MT	

[1] 1993 estimates from surveys conducted by Montana Fish, Wildlife and Parks from Lemke (1996).

[2] General population status, distribution, and ecology information specific to these populations.

at 3) or 3.5 (these goats give birth at 4), depending upon conditions (Houston and Stevens 1988), though productive conditions can, in rare cases, lead to maturity at the age of 1.5 (Stevens 1983). Gestation is about 6 months, and offspring are born in late May or early June. Females most often have one offspring. Though two and even three kids have been documented, it is considered rare and an indication of productive conditions (Lentfer 1955, Foss 1962, Hayden 1984, Houston and Stevens 1988, Festa-Bianchet et al. 1994, Varley 1995). Mountain goat kids often remain with their mothers for 10–11 months, or longer if the mother does not produce a new kid. Because of social aggression, the association between a mother and kid can be critical to kid survival during winter (Chadwick 1977). At age two or three, males leave female groups and join male groups or become solitary, while females typically stay with groups (Brandborg 1955, Wigal and Coggins 1982, Chadwick 1983). Both sexes are capable of dispersing long distances and often will at young ages (Chadwick 1973, Stevens 1983, Hayden 1989, Varley 1995).

The greatest factor in natural mortality of mountain goats appears to be winter severity and, in particular, snow depths (Adams and Bailey 1982, Wigal and Coggins 1982, Swenson 1985). Snow depth and snow morphology are often the underlying factors in the causes of death in mountain goats. Causes of death include the availability of winter forage and its effect on body condition (Brandborg 1955, Edwards 1956, Holroyd 1967); the frequency of intraspecific interactions and the resulting levels of stress (Petocz 1972, Chadwick 1977, Kuck 1977, Smith 1977, Foster and Rahs 1982); the susceptibility to accidents, including avalanches and falls (Holroyd 1967, Chadwick 1983, Smith 1984); the susceptibility to disease and parasites (Wigal and Coggins 1982); and the susceptibility to predation (Brandborg 1955, Holroyd 1967, Foster and Rahs 1982). Of all natural causes, accidents related to avalanches; rock, snow, and ice fall; and precipitous falls appear to account for most natural deaths (Brandborg 1955, Holroyd 1967, Foster and Rahs 1982, Wigal and Coggins 1982, Chadwick 1983, Smith 1984).

HABITAT

Throughout their range, mountain goats inhabit steep, rocky terrain during all seasons of the year. No other feature of preferred habitat is more apparent than the rugged inclines to which goats are adapted. They are often found on slopes between 20 and 60 degrees with little vegetative cover (Smith 1977, Varley 1995). They use cliff ledges for all activities including resting, feeding, and playing (Chadwick 1973, McFetridge 1977). They also use the slide-rock, talus, and turf meadows adjacent to ledges, though they rarely stray far from the safety of cliff habitat (Saunders 1955, McFetridge 1977, Varley 1995).

Goats typically migrate between summer and winter ranges each fall and spring (Brandborg 1955, Holroyd 1967, Kuck 1977, Smith 1977, Wigal and Coggins 1982). These migrations are often short-distance elevational shifts to adjacent areas, versus the lengthy migrations to distantly separated ranges known to occur with mountain sheep and elk (Holroyd 1967, Chadwick 1973, Varley 1995). The use of transitional ranges between summer and winter ranges is atypical (Kuck 1977).

In the Rocky Mountains, summer ranges are often high-elevation settings such as the tops of mountain ridges and peaks above timberline (Brandborg 1955, Holroyd 1967, Wigal and Coggins 1982). In the GYA, these areas are typically between 8,500 and 12,000+ feet in elevation. During the summer months, goats use alpine meadows, slide-rock slopes, talus, and cliff ledges and usually avoid timbered areas (Saunders 1955, McFetridge 1977, Thompson 1981, Varley 1995).

Goats descend to lower elevations in autumn, often after the first deep snowfall, and use terrain topographically similar to their high-elevation habitats. In some populations, goats remain in high-elevation areas during the winter and feed on very steep and/or wind-blown slopes and ridges where snow does not accumulate (Brandborg 1955, Saunders 1955, Hebert and Turnbull 1977, Wigal and Coggins 1982), however, most populations have winter ranges distinctly lower in elevation (Brandborg 1955, Chadwick 1973, Kuck 1977, Wigal and Coggins 1982). Winter habitats can be below timberline, varying in elevation depending upon local topography, though the particular areas in use for non-coastal populations tend to be non-forested areas or open-canopied forests (Gilbert and Raedeke 1992).

The principal factors in mountain goat winter range habitat selection seem to be close proximity to cliff habitats and low snow accumulations (Brandborg 1955, Smith 1977, Smith 1994). Thus, the preferred habitats are often steep and rocky, located on south-facing slopes, and exposed to wind and sun (Brandborg 1955, Chadwick 1973, Gilbert and Raedeke 1992, Smith 1994, Varley 1995). Brandborg (1955) noted that goats in Montana and Idaho used the lowest available winter ranges that provide preferred combinations of broken terrain and vegetative cover. Smith (1977) found wintering goats in the Bitterroot Range used cliff habitats more than 70 percent of the time observed. Kuck (1977) found the selection of winter habitat for goats in the Lemhi Mountains of Idaho was determined by the physical snow-shedding characteristics of an area rather than the forage types present.

Wintering goats show strong affinity for local sites where they restrict their movements dramatically in comparison with summer. The resulting distribution is often confined to critically small islands of habitat (Kuck 1977). In the Bitterroot Range, 36 goats occupied a linear distance of 3 miles throughout the winter (Smith 1977). Similarly, 17 wintering goats used 8.6 acres in the Swan Range of northern Montana (Chadwick 1973). In very severe winters, goats continue descending to lower elevations (Rideout 1977) or ascend to wind-swept ridges or mountain tops (Hjeljord 1973).

Various winter ranges in the GYA have been described. Peck (1972) reported goats using the Spanish Peaks area of the Madison Range moved to lower elevation winter ranges in Jack Creek and the Beartrap Canyon of the Madison River. Similarly, goats on the Beartooth Plateau are known to descend into the rocky canyons of drainages on the eastern front, including the Clarks Fork Canyon in Wyoming. There, they may be found as low as 5,000 feet in elevation. Mountain goats in the Crazy Mountains are thought to stay close to alpine areas using wind-swept ridges and cliffs (Lentfer 1955; T. Lemke, Montana Fish, Wildlife and Parks, personal communication). In the Absaroka Range, goats are thought to descend to low, south-facing slopes and cliffs adjacent to summer ranges (T. Lemke, Montana Fish, Wildlife and Parks, personal communication; Varley 1995). One area of the Boulder River Canyon, which had steep semi-forested rock outcrops, was used by goats from the Absarokas in 1994 (Varley 1995).

HUMAN ACTIVITIES

Mountain goats are one of the least understood of all big game mammal species in North America (Eastman 1977, Chadwick 1983). Management has principally focused on the need for better population information and methods for setting harvest quotas (Brandborg 1955, Eastman 1977, Wigal and Coggins

1982). Eastman (1977) assessed research needs for goats in the U.S. and Canada and found non-hunting impacts resulting from human disturbance ranked within the top third among management priorities, though very little had been done on the subject.

Some human disturbances have been shown to alter goat behavior, and disturbance can affect physiology, distribution, habitat use, fecundity, and, ultimately, population health (Penner 1988). However, there is little known about winter recreation disturbances and their effects on mountain goats.

Throughout North America, some goat populations have been adversely affected by human developments, including logging (Chadwick 1973, Hebert and Turnbull 1977, Smith and Raedeke 1982) and mineral, coal, gas, and oil development (Hebert and Turnbull 1977, Pendergast and Bindernagel 1977, Smith 1982, Joslin 1986). These cases have predictive value for estimating the general effects of continual disturbance through human activities. In these cases, a decline in goat population levels occurred when development in or near goat habitats took place. The mechanisms for population declines were not clear but seem to be related to improved access for hunting or poaching (Chadwick 1973, Foster 1977, Hebert and Turnbull 1977, Smith and Raedeke 1982, Smith 1994), abandonment of habitat due to alterations or disturbance (Chadwick 1973, Hebert and Turnbull 1977, Pendergast and Bindernagel 1977), or continual stress as a result of human presence (Joslin 1986).

Controlling human access has been continually suggested as the management tool that will have the greatest effects on the long-term health of mountain goat populations (Chadwick 1973, 1983; Eastman 1977, Hebert and Turnbull 1977, McFetridge 1977, Wigal and Coggins 1982, Joslin 1986, Haynes 1992). Joslin (1986) states, “Motorized access in or near mountain goat habitat is probably the single biggest threat to goat herds throughout North America.”

Several authors have looked at the effects of human disturbance on goats in the form of proximity to people, traffic, and noise during summer (Holroyd 1967, Singer 1978, Thompson 1980, Singer and Doherty 1985, Pedevillano and Wright 1987). Goats have shown tolerance, and, in cases without harvest or harassment, the ability to readily habituate to humans on foot as well as road traffic (Bansner 1978, Stevens 1983, Singer and Doherty 1985, Pedevillano and Wright 1987, Penner 1988). Penner (1988) writes, “Goats are adaptable and can habituate to potentially adverse stimuli if they are gradually acclimatized and negative associations are avoided.” This possibility is best achieved when stimuli sources are localized and highly predictable (Penner 1988, Singer and Doherty 1985). Sudden, loud noises, however, from traffic (Singer 1978, Singer and Doherty 1985, Pedevillano and Wright 1987), blasting or drills (Singer and Doherty 1985, Penner 1988), and helicopters (Penner 1988, Coote 1996) still elicited extreme alarm responses from goats that have been habituated to human presence.

Many observers have found that goats that are approached on foot are either mildly evasive, tolerant, or curious. Consequently, these observers believe that most human foot traffic is of minimal impact to goats (Brandborg 1955, Holroyd 1967, Thompson 1980, Pedevillano and Wright 1987). Although quite rare, confrontations with aggressive goats have been reported when humans and goats come into close quarters (Holroyd 1967, Chadwick 1983). Goats react by stamping their front feet, pawing the ground, and arching their necks when threatened by humans (Holroyd 1967). Quick, powerful movements coupled with very sharp horns can cause serious injury to humans in the course of handling goats. Anecdotal reports of goats on the Beartooth Plateau attest to the occasional aggressive nature of goats around humans. Driven by hunger for minerals, these goats have, on occasion, come into human camps knocking down tents and equipment.

Some biologists in the GYA have expressed concern about potential conflicts between humans and goats, but there are no documented, actual, ongoing conflicts. Outside the GYA on the Sawtooth National Forest and Sawtooth National Recreation Area in Idaho, special management restrictions on winter recreation, including foot, snow machine, and helicopter travel, have been established. Mitigation measures, including area restrictions, closures, and other regulations, were enacted to minimize the potential for disturbances to wintering goat populations (Hamilton et al. 1996, USFS 1997).

POTENTIAL EFFECTS

Human activities are capable of causing disturbances detrimental to mountain goat populations. While the cases that exist do not specifically refer to winter recreation, they do demonstrate the process by which human impact may alter goat behavior, habitat use, and stress levels potentially leading to population declines. Because of low productivity and narrow habitat requirements, goats can be considered a fragile wildlife resource, particularly while on winter ranges (Smith 1982, Chadwick 1983, Smith 1984, Wigal and Coggins 1988).

Because of the remote and rugged nature of goat wintering habitats, recreational use of such areas is unlikely. However, any use could potentially be detrimental. Abandonment of habitats or increased stress related to frequent encounters could be elicited through recreational activities including snowmobiling, skiing (downhill, cross-country, or telemark skiing accessed by helicopter or from the ground), snow-boarding, and ice-climbing.

Because mountain goats are sensitive to loud noises, snowmobiles and helicopters could affect their behavior depending upon the proximity and duration of the disturbance (Singer and Doherty 1985, Pedevillano and Wright 1987, Côté 1996). In the GYA, most occupied goat winter range occurs within established national wilderness areas where motorized travel is strictly prohibited. In assessing management considerations, the Idaho Department of Fish and Game identified use of helicopters for skiing as an activity potentially detrimental to goats. Where the two are in conflict, goats require protection (Idaho Department of Fish and Game 1990).

Nonmotorized users in close proximity to wintering goats may also affect goats in terms of the energy expended to avoid these users. Depending upon winter severity, energy expended avoiding recreationists could be costly and, therefore, cause harm to individuals and, in the long-term, to populations. Biologists have expressed concerns about an increasing amount of ice-climbing taking place in mountain goat habitats. The extent of this potential disturbance is unknown. Ice climbing may need to be monitored as a potential source of disturbance in particular situations, although, because it is a highly localized activity lacking loud noises or other disturbance factors, long-term effects would likely be minimal.

Although accounts of goats injuring humans exist, goats generally do not pose a safety hazard to humans. Only in unusual cases involving habituated goats in frequent, close proximity to humans would such a concern exist.

Mountain goats in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(6) Backcountry motorized areas
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(12) Low-snow recreation areas

Given the susceptibility of mountain goats to human disturbance, particularly during the months of winter, there is potential for negative impacts to goats as a result of winter recreational activities. However, there are no known cases of conflict in the GYA at this time. Seemingly, conflicts are being avoided between winter recreationists and mountain goats. Possible explanations for this conclusion include:

1. Conflicts may be occurring that are unknown to officials. It would be likely that any major conflicts would not escape attention, though the occasional, minor conflict could go unreported for some time. Minor conflicts may occur in association with wilderness trespasses and, thus, remain unreported or undetected. In most cases, it appears that wilderness designation and area use limitations have adequately protected mountain goat habitats from motorized-related disturbances in the GYA.
2. Because mountain goat winter range is inaccessible and precipitous, goats and recreationists are not often coming into conflict. For recreation, humans tend not to seek the combination of rocky, rugged terrain, and low-snow conditions required by mountain goats. Rather, snowmobilers and skiers prefer deep snow conditions, which are typically avoided by goats. The discrepancy in site preferences appears to be a factor in mutual avoidance by goats and humans during winter. While ice climbing does occur in goat winter range habitats, the effects of this form of recreation are unknown. Ice climbing is localized at specific sites and is predictable in terms of repeated use. These are two characteristics that goats seem to require for tolerance or habituation; therefore, ice climbing may not pose a significant threat to goats.

Management Guidelines

The impacts of human disturbance on goat populations have been clearly demonstrated in numerous cases; however, these cases conspicuously lack a clear case demonstrating the effects of recreation on goats during winter. Based on no known cases of conflict in the GYA, no immediate management recommendations are offered. If, however, cases of conflict occur in the future, restrictions on human use should be implemented to protect mountain goats. Such restrictions might include area closures, a permitting system that would regulate visitor numbers, and criteria for the use of helicopters in the area of mountain goat winter range.

A general lack of information on the winter habits and resource requirements for mountain goats may require further ecological studies. It would be useful to more specifically locate mountain goat winter ranges in the GYA and compare them with backcountry recreation use areas. Overlap can then be examined so that potential areas for conflict can be identified. If a significant overlap exists or conflict arises, management options can be considered and implemented.

Literature Cited

Adams, L. A., and J. A. Bailey. 1982. The population dynamics of mountain goats in the Sawatch Range, Colorado. Journal of Wildlife Management 46:1003–1009.

Bansner, U. 1978. Mountain goat–human interactions in the Sperry-Gunsight area of Glacier National Park. Final report, University of Montana.

Brandborg, S. M. 1955. Life history and management of the mountain goat in Idaho. Idaho Department of Fish and Game, Bulletin Number 2.

Chadwick, D. H. 1973. Mountain goat ecology-logging relationships in the Bunker Creek Drainage of Western Montana. Thesis, University of Montana, Missoula, Montana, USA.

———. 1977. The influence of mountain goat social relationships on population size and distribution. Pages 74–91 *in* W. Samuel and W. G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada.

———. 1983. A beast the color of winter. Sierra Club Books, San Francisco, California, USA.

Côté, S. D. 1996. Mountain goat responses to helicopter disturbance. Wildlife Society Bulletin 24(4):681–685.

Eastman, D. S. 1977. Research needs for mountain goat management. Pages 160–168 *in* W. Samuel and W. G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada.

Edwards, R. Y. 1956. Snow depth and ungulate abundance. Journal of Wildlife Management 20(2):159–168.

Festa-Bianchet, M., M. Urquhart, and K. G. Smith. 1994. Mountain goat recruitment: kid production and survival to breeding age. Canadian Journal of Zoology 72:22–27.

Foss, A. J. 1962. A study of the Rocky Mountain goat in Montana. Thesis, Montana State University, Bozeman, Montana, USA.

Foster, B. R. 1977. Historical patterns of mountain goat harvest in British Columbia. Pages 147–159 *in* W. Samuel and W. G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada.

———, and E. Y. Rahs. 1982. Implications of maternal separation on overwinter survival of mountain goat kids. Biennial Symposium of the Northern Wild Sheep and Goat Council 3:351–363.

Gilbert, B. A., and K. J. Raedeke. 1992. Winter habitat selection of mountain goats in the North Tolt and Mine Creek drainages of the North Central Cascades. Biennial Symposium of the Northern Wild Sheep and Goat Council 8:305–324.

Hamilton, S., J. Carlisle, and R. Garwood. 1996. Human effects on mountain goats in the Sawtooth National Forest. Sawtooth National Recreation Area. Headquarters, Star Route, Ketchum, Idaho, USA.

Hayden, J. A. 1984. Introduced mountain goats in the Snake River Range, Idaho: characteristics of vigorous population growth. Biennial Symposium of the Northern Wild Sheep and Goat Council 4:94–119.

———. 1989. Status and dynamics of mountain goats in the Snake River Range. Thesis, University of Montana, Missoula, Montana, USA.

Haynes, L. A. 1992. Mountain goat habitat of Wyoming's Beartooth Plateau: implications for management. Biennial Symposium of the Northern Wild Sheep and Goat Council 8:325–339.

Hebert, D. H., and W. G. Turnbull. 1977. A description of southern interior and coastal mountain goat ecotypes in British Columbia. Pages 126–146 *in* W. Samuel and W. G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada.

Hjeljord, O. G. 1973. Mountain goat forage and habitat preference in Alaska. Journal of Wildlife Management 37:353–362.

Holroyd, J. C. 1967. Observations of Rocky Mountain goats on Mount Wardle, Kootenay National Park, British Columbia. Canadian Field Naturalist 81(1):1–22.

Houston, D. B., and V. Stevens. 1988. Resource limitation in mountain goats: a test by experimental cropping. Canadian Journal of Zoology 66:228–238.

Idaho Department of Fish and Game. 1990. Mountain goat management plan, 1991–1995. Boise, Idaho, USA.

Johnson, R. L. 1977. Distribution, abundance, and management status of mountain goats in North America. Pages 1–7 *in* W. Samuel and W. G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada.

Joslin, G. 1986. Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain Front. Biennial Symposium of the Northern Wild Sheep and Goat Council 5:253–271.

Kuck, L. 1977. The impacts of hunting on Idaho's Pahsimeroi mountain goat herd. Pages 114–125 *in* W. Samuel and W. G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada.

Laundre, J. W. 1990. The status, distribution, and management of mountain goats in the greater Yellowstone ecosystem. National Park Service, Yellowstone National Park, Wyoming, USA.

Lemke, T. 1996. Pittman-Robinson Project Report Southwest Montane Eco-Region Survey and Inventory Project (Mountain Goats). Montana Fish, Wildlife and Parks report, Montana, USA.

Lentfer, J. W. 1955. A two-year study of the Rocky Mountain goat in the Crazy Mountains, Montana. Journal of Wildlife Management 19:417–429.

McFetridge, R. J. 1977. Strategy of resource use by mountain goat nursery groups. Pages 169–173 *in* W. Samuel and W. G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada.

Montana Department of Fish and Game. 1976. Montana big game trapping and transplant record 1910–1975. Unpublished report.

Peck, S. V. 1972. The ecology of the Rocky Mountain goat in the Spanish Peaks area of southwestern Montana. Thesis, Montana State University, Bozeman, Montana, USA.

Pedevillano, C., and R. G. Wright. 1987. The influence of visitors on mountain goat activities in Glacier National Park, Montana. Biological Conservation 39:1–11.

Pendergast, B., and J. Bindernagel. 1977. The impact of exploration of coal on mountain goats in northeastern British Columbia. Pages 64–68 *in* W. Samuel and W. G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada.

Penner, D. F. 1988. Behavioral response and habituation of mountain goats in relation to petroleum exploration at Pinto Creek, Alberta. Biennial Symposium of the Northern Wild Sheep and Goat Council 6:141–158.

Petocz, R. G. 1972. The effect of snow cover on the social behavior of bighorn rams and mountain goats. Canadian Journal of Zoology 51:987–993.

Rideout, C. B. 1977. Mountain goat home ranges in the Sapphire Mountains of Montana. Pages 201–211 *in* W. Samuel and W. G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada.

Saunders, J. K. 1955. Food habits and range use of the Rocky Mountain goat in the Crazy Mountains, Montana. Journal of Wildlife Management 19:429–437.

Singer, F. J. 1978. Behavior of mountain goats in relation to U.S. Highway 2, Glacier National Park, Montana. Journal of Wildlife Management 42(3)591–597.

———, and J. L. Doherty. 1985. Managing mountain goats at a highway crossing. Wildlife Society Bulletin 13:469–477.

Smith, B. L. 1977. Influence of snow conditions on winter distribution, habitat use, and group size of mountain goats. Pages 174–189 *in* W. Samuel and W. G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada.

Smith, C. A. 1984. Evaluation and management implications of long-term trends in coastal mountain goat populations in southeast Alaska. Biennial Symposium of the Northern Wild Sheep and Goat Council 4:395–424.

———. 1994. Evaluation of a multivariate model of mountain goat winter habitat selection. Biennial Symposium of the Northern Wild Sheep and Goat Council 9:159–165.

———, and K. J. Raedeke. 1982. Group size and movements of a dispersed, low density goat population with comments on inbreeding and human impact. Biennial Symposium of the Northern Wild Sheep and Goat Council 3:54–67.

Smith, K. G. 1982. Winter studies of forest-dwelling mountain goats of Pinto Creek, Alberta. Biennial Symposium of the Northern Wild Sheep and Goat Council 3:374–390.

Stevens, V. 1983. The dynamics of dispersal in an introduced mountain goat population. Dissertation, University of Washington, Seattle, Washington, USA.

Swenson, J. E. 1985. Compensatory reproduction in an introduced mountain goat population in the Absaroka Mountains, Montana. Journal of Wildlife Management 49:837–843.

Thompson, M. J. 1981. Mountain goat distribution, population characteristics and habitat use in the Sawtooth Range, Montana. Thesis, Montana State University, Bozeman, Montana, USA.

Thompson, R. W. 1980. Population dynamics, habitat utilization, recreational impacts, and trapping of introduced Rocky Mountain goats in the Eagle's Nest Wilderness area, Colorado. Biennial Symposium of the Northern Wild Sheep and Goat Council 2:459–464.

USFS (U.S. Forest Service). 1997. Environmental assessment for outfitted and guided backcountry helicopter skiing on the Sawtooth National Forest. U.S. Forest Service, Sawtooth National Forest, Ketchum, Idaho, USA.

Varley, N. 1995. The ecology of mountain goats in the Absaroka Range, south-central Montana. Thesis, Montana State University, Bozeman, Montana, USA.

Wigal, R. A., and V. L. Coggins. 1982. Mountain goat. Pages 1008–1020 *in* J. A. Chapman and G. A. Feldhamer, editors. Wild mammals of North America: biology, management, and economics. John Hopkins University Press, Baltimore, Maryland, USA.

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EFFECTS OF WINTER RECREATION ON SUBNIVEAN FAUNA

Subnivean fauna are small animals that live under the snow during the winter. They include such species as shrews, voles, pocket gophers, and mice.

LIFE HISTORY

Subnivean mammals are often active both day and night and are active throughout the year. They spend most of their time in or on the ground, and, during winter, they are most often found under the snow. Generally they are short lived but have relatively high reproductive rates.

These mammals eat a wide variety of foods that can be obtained from above or below the ground. Shrews eat primarily insects, other invertebrates, and some small mammals. A vole's diet may include green vegetation (grasses, seeds, grain, and bark). Tubers, roots, and some types of surface vegetation are preferred by pocket gophers, and mice generally feed on seeds, insects, or green vegetation.

Ecologically, these mammals are important prey species for a wide variety of birds and mid-sized carnivores.

HUMAN ACTIVITIES

It has been suggested that compacting snow by mechanical grooming or even by substantial activity on foot (skiing or snowshoeing) could have a negative impact on small mammals that spend their time under the snow in the winter.

POTENTIAL EFFECTS

The subnivean environment protects life below the snow from some impacts of winter, such as wind and cold. The environment under the snow has relatively stable temperatures, and the loss of energy from the organisms that live there is slowed. However, factors such as light, carbon dioxide, oxygen, and moisture may have more effect on the animals that live in this environment than on those that live above the snow (Halfpenny & Ozanne 1989).

Light penetration to plants under the snow may initiate plant growth and seed germination late in the winter, thereby providing a food source for mammals. Consumption of plants with phenolic compounds (which are found in growing grasses and other plants) is possibly a cue for the initiation of the reproduction process in some mammals (Halfpenny & Ozanne 1989). Carbon dioxide may accumulate in varying levels of concentration under the snow. Higher concentrations of carbon dioxide may affect the physiological functions of plants and animals, possibly resulting in the reduced ability of subnivean animals to find food or avoid predators (Halfpenny & Ozanne 1989). Water running through snowpack can cause flooding at ground level and below, and, especially during spring runoff, subnivean animals may drown or die of hypothermia (Halfpenny & Ozanne 1989).

Most research relating to the impacts of winter recreation on subnivean fauna has concerned the effects of snow compaction due to snowmobiles on the animals. One of the potential impacts of snow compaction is alteration of the snow microclimate, especially the physical and thermal aspects (Corbet 1970). Some of the possible changes in snow conditions resulting from snow compaction include a decrease in subnivean air space, a change in temperature, and accumulation of toxic air under the snow (Jarvinen and Schmid 1971, Schmid 1971a and b). Temperature changes may result in animal movements under the snow being limited, the suitability of a site for seed germination being reduced, and winter mortality of subnivean wildlife being increased (Keddy et al. 1979). There is a possibility that carbon dioxide could accumulate under the snow to levels that are toxic to small mammals. Carbon dioxide tends to flow downhill. If a compacted area is located at the bottom of a hill or even on a side slope, carbon dioxide accumulation could be fatal to the small mammals attempting to move through the area under the snow (H. Picton, Montana State University, personal communication).

According to Halfpenny & Ozanne (1989), skiers may do more damage to the snowpack than snowmobilers because narrow skis cut deeper into the snowpack and because skis have a greater footload (amount of weight per surface area) in comparison to a snowmobile track. For both ski tracks and snowmobile tracks, multiple passes over the same track will have more impact than a single pass. The larger the area of compaction, the greater the possible impact to subnivean fauna. If the habitat area is small, if rare species are present in the area, or if the activity is not restricted to narrow paths, impacts to subnivean life may be substantial and damaging (Halfpenny & Ozanne 1989).

Subnivean fauna in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(4) Groomed motorized routes
(5) Motorized routes
(7) Groomed nonmotorized areas

MANAGEMENT GUIDELINES

The lack of information about impacts to subnivean mammals from winter use makes it difficult to draw conclusions. However, there is the potential for an increase in winter mortality of these animals because of the impacts of snow compaction. Until more research is completed in this area, the only management guideline is to encourage more research on the subject, especially in areas where widespread and high intensity snowmobiling or skiing occurs near comparison control areas.

LITERATURE CITED

Corbet, P. S. 1970. Snowmobiles: for pleasure, profit, and pollution. Ontario Naturalist 8(2):10–12.

Halfpenny J. C., and R. D. Ozanne. 1989. Winter: an ecological handbook. Johnson, Boulder, Colorado, USA.

Jarvinen, J. A., and W. D. Schmid. 1971. Snowmobile use and winter mortality of small mammals. Pages 130–140 *in* M. Chubb, editor. Proceedings of the 1971 Snowmobile and Off-the-Road Vehicle Research Symposium. Technical Report Number 8, Recreation, Research and Planning Unit, Department of Park and Recreation Resources. Michigan State University, East Lansing, Michigan, USA.

Keddy, P. A., A. J. Spaovld, and C. J. Keddy. 1979. Snowmobile impact on old field and marsh vegetation in Nova Scotia, Canada: an experimental study. Environmental Management 3:409–415.

Schmid, W. D. 1971a. Modification of the subnivean microclimate by snowmobiles. Pages 251–257 *in* Proceedings of symposium on snow and ice in relation to wildlife and recreation. Cooperative Wildlife Resources Unit, Iowa State University, Ames, Iowa, USA.

———. 1971b. Snowmobile activity, subnivean microclimate, and winter mortality of small mammals. Bulletin of the Ecological Society of America 53(2):37.

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BIRDS

Photo courtesy of the National Park Service

EFFECTS OF WINTER RECREATION ON BALD EAGLES

POPULATION STATUS AND TREND

Nesting, wintering, and migrating populations of bald eagles (*Haliaeetus leucocephalus*) occur in the Greater Yellowstone Area (GYA). Bald eagles are protected under the Migratory Bird Treaty Act of 1918 (16 U.S. Code 703) and the Bald Eagle Protection Act of 1940 (16 U.S. Code 668). Bald eagles were initially listed as an endangered species under the Endangered Species Act of 1973 (U.S. Code 1531, 1982 amended), but on July 12, 1995, the bald eagle's status was downlisted to threatened in the lower 48 states. This action did not alter those conservation measures already in place to protect the species and its habitats.

Because of the eagle's initial status as endangered, the Pacific States Bald Eagle Recovery Team was formed (the GYA is part of the Pacific Recovery Area). The team produced the Pacific Bald Eagle Recovery Plan (USFWS 1986), which addressed the recovery of bald eagles in Washington, Oregon, California, Nevada, Idaho, Montana, and Wyoming. Regionally, other teams were formed, and the Bald Eagle Management Plan for the Greater Yellowstone Ecosystem was issued in 1983 (revised 1996), and the Montana Bald Eagle Management Plan was issued in 1986 (revised 1994). Both plans identify threats to the bald eagle and provide management direction for population recovery in the respective areas.

Three population units were delineated in the GYA based on bald eagle natural history and the elevation, climate, and vegetation of the units (GYBEWG 1996). The Snake Unit includes bald eagle breeding areas associated with the Snake River in northwestern Wyoming and southeastern Idaho. The Continental Unit includes the watersheds in southwestern Montana, the upper Henrys Fork, southeastern Idaho, and northwestern Wyoming. The Yellowstone Unit includes most of Yellowstone National Park.

Between 1970 and 1995, the bald eagle population in the GYA increased exponentially. There were 111 known breeding areas in 1995 (GYBEWG 1996). Population growth has been attributed to the significant reduction of environmental contaminates, such as DDT (pesticide), and the initiation of intensive nesting surveys (Flath et al. 1991).

LIFE HISTORY

The average life span of a wild bald eagle is estimated to be between 10 and 18 years (MBEWG 1994). Bald eagles first breed at 6 to 7 years (Harmata and Oakleaf 1992) after adult plumage is acquired (Stalmaster 1987). Nest building most commonly occurs during the autumn, late winter, and early spring (October to April), although nest repair may occur during every season for well-established pairs. Alternate nests may be present in a breeding area. Incubation can begin as early as the first week of February and as late as the last week of March (Swensen et al. 1986, Harmata and Oakleaf 1992, Whitfield 1993, Stangl 1994) and lasts 35 days. Bald eagles are very sensitive to disturbance during nest building, egg laying, and incubation.

Bald eagles are opportunistic feeders and prey on fishes, waterfowl, lagamorphs, some ground-dwelling mammals, as well as ungulate carrion. Bald eagles also steal prey from other eagles, osprey, otters, and many other species (Stalmaster 1987, Harmata and Oakleaf 1992, Stangl 1994).

In the GYA, adult breeding pairs of eagles may or may not migrate out of the ecosystem during the winter (Harmata and Oakleaf 1992). Juvenile, immature, and adult eagles migrate at different times, therefore, age ratios of a population may differ during the winter. Juveniles migrate earlier in the autumn (Stalmaster 1987, Harmata and Oakleaf 1992) and may travel farther than sub-adults or adults (Stalmaster 1987). Band encounters and radio tracking of juvenile and immature bald eagles produced in the GYA indicated that virtually all birds leave the ecosystem in the first autumn after fledging. Juveniles return in mid-April to early May and appear to remain within the GYA during the summer. Juvenile eagles originating in Canada winter within the GYA.

HABITAT

WINTERING HABITAT

Bald eagle winter habitat is generally associated with areas of open water (unfrozen portions of lakes and free-flowing rivers) where fishes and/or waterfowl congregate (Swensen et al. 1986, Stalmaster 1987, GYBEWG 1996). Most winter habitats include major rivers and large lakes. Eagles will forage on high-quality foods away from aquatic areas, in particular, upland areas where ungulate carrion, game birds, and lagomorphs are available (Swenson et al. 1986). Ungulate carrion associated with late-season hunter harvests and big game wintering areas are also important to wintering bald eagles (GYBEWG 1996).

NESTING HABITAT

Nesting habitat varies among units in the GYA. Nest sites are generally distributed around the periphery of lakes, reservoirs, and along rivers. Nests are most commonly constructed in mature or old-growth stands of large diameter trees that are multi-layered and contain a variety of species, primarily Douglas fir (*Pseudotsuga menziesii*), black cottonwood (*Populus trichocarpa*), and spruce (*Picea* spp.). Large emergent trees and snags provide important nesting and perching habitat (Wright and Escano 1986). Bald eagles display strong fidelity to a breeding area and often to a specific nest.

An available prey base may be the most important factor determining nesting habitat suitability (Swensen et al. 1986, Harmata and Oakleaf 1992, MBEWG 1994), nesting density (Dzus and Gerrard 1993), and productivity (Hansen 1987) of bald eagles. Bald eagles usually nest as close to maximum foraging opportunities as possible, although human activity will be avoided (Harmata and Oakleaf 1992).

ROOSTING HABITAT

Like nesting and perching trees, roost trees are typically mature or old conifers or cottonwoods. Preferred roosting habitat includes a protected microclimate that provides shelter from harsh weather and is characterized by tall trees that extend above the forest canopy and by locations that provide clear views and open flight paths (Stalmaster 1987). Roost locations lie within the breeding territory during the breeding season. Bald eagles may roost in the nest or nest tree. As nestlings grow, the adults may roost farther away from the nest site (Stalmaster 1987).

In many areas, night communal roosts are important during the fall and winter months. Although winter roosting habitat is not necessarily close to water or in close proximity to food sources, the availability of an abundant source of food, of foraging perches, and of secure night-roost sites away from human activities are important habitat components (GYBEWG 1996, MBEWG 1994).

HUMAN ACTIVITIES

Bald eagles may be affected by a variety of recreational, research, resource, and urban development activities. Pesticides, poisoning, electrocution, vehicle collisions, and shooting have directly affected eagles. Various types of human activities that influence the environment have indirectly affected eagles (Mathisen 1968, Knight and Knight 1984, Stalmaster 1987, Buehler et al. 1991, McGarigal et al. 1991, Harmata and Oakleaf 1992).

Management concerns initially focused on permanent alterations of bald eagle habitat, such as cutting down nest trees. However, recent studies have demonstrated the importance of protecting eagle habitat from temporary human activities, such as recreation (Stalmaster and Newman 1978, Knight and Knight 1984, Knight et al. 1991, McGarigal et al. 1991, Harmata and Oakleaf 1992). Many recreational activities are focused on or around major water bodies where bald eagles nest, roost, or forage, thereby increasing the potential for eagle–human interactions.

Temporary human activities have been shown to influence the behavior of wintering bald eagles (Stalmaster and Newman 1978, Knight and Knight 1984) and those in breeding areas (McGarigal et al. 1991, Harmata and Oakleaf 1992, Stangl 1994). Anthony et al. (1995) believe that the cumulative effects of recreational activities can have deleterious effects on eagle populations through reductions in survival, especially during the winter, and in reduced reproductive success (Montolopi and Anderson 1991).

POTENTIAL EFFECTS

Bald eagles are generally food-stressed during winter. High levels of human activity can potentially increase energy demands on wintering bald eagles and result in increased mortality rates (Stalmaster and Gessaman 1984). Juvenile bald eagles have higher energy demands, are less efficient foragers, and spend more time trying to acquire food than adults. Therefore, they are more likely to be adversely impacted by human activities.

During the breeding season, bald eagles are most sensitive to human activities during nest building, egg-laying, and incubation (February 1 to May 30). Human activities during this time may cause nest abandonment. After young have hatched, a breeding pair is less likely to abandon the nest. However, eagles may leave the nest due to prolonged disturbances, exposing young to predation and adverse weather conditions (MBEWG 1994, GYBEWG 1996).

Bald eagle responses to human activities generally range from displacement to avoidance of the human activity to reproductive failure. Bald eagle responses also vary depending on type, intensity, duration, timing, predictability, and location of the human activity. Responses may be influenced by the presence of another eagle nearby, the eagle's physical and behavioral state, the nature of the human activity, and the time and location of the encounter (Anthony et al. 1995). Eagle responses to human activities may differ with populations (Fraser et al. 1985) and with individual pairs (Stangl 1994). Some bald eagles may habituate to human presence and become more tolerant of human activities (Knight and Knight 1984, Harmata and Oakleaf 1992, GYBEWG 1996).

Human activities during the winter and spring can reduce feeding activities of bald eagles (Skagen 1980). These activities can also displace eagles from foraging areas (Stalmaster and Newman 1978), alter use patterns (*i.e.*, eagles will avoid a feeding area for a period of time), or shift spatial- or temporal-use patterns (McGarigal et al. 1991, Harmata and Oakleaf 1992, Stangl 1994, Smith 1988).

Vehicular activities along prescribed routes or within strict spatial limits and at relatively predictable frequencies are least disturbing to bald eagles (McGarigal et al. 1991, Stangl 1994, GYBEWG 1996). However, slow-moving motor vehicles can disrupt eagle activities more than fast-moving motor vehicles (McGarigal et al. 1991). Snowmobiles may be especially disturbing, probably due to associated random movement, loud noise, and operators who are generally exposed (Walter and Garret 1981).

Bald eagles have been displaced by pedestrian activities (Stalmaster and Newman 1978, McGarigal et al. 1991, Stangl 1994) especially when the activities occur outside of predictable use areas (Harmata and Oakleaf 1992). Grubb and King (1991) found that pedestrians (hikers, anglers, and hunters) were the most disruptive type of human activities to bald eagles. Stangl (1994) found that a bald eagle pair used perches that were spatially separated from pedestrian angler activities. Bald eagles that forage on the ground are most sensitive to human activities (Stalmaster and Newman 1978, Knight and Knight 1984, McGarigal et al. 1991), therefore, human disturbances may have a greater impact on eagles foraging on fish or ungulate carcasses (Anthony et al. 1995).

Riparian habitat is an important component of bald eagle habitat. Recreational impacts on riparian areas, specifically impacts to cottonwood trees, could affect bald eagle perch habitat as well as availability of prey.

In the GYA, winter recreational activities that are most likely to affect wintering, migrating, and spring nesting bald eagles include: snowcoach and snowmobile traffic, cross-country skiing, telemark skiing, snowshoeing, dog sledding, late-season elk hunting, and antler collecting. (Bison management activities also have the potential to impact bald eagles.) Groomed trails are often located in riparian areas, and activities on these trails can begin as early as October and extend as late or later than June. A review of the literature revealed that research has not been completed to assess the effects of snowmobile or other winter recreational activities on bald eagle wintering or breeding habitat, but some documents referenced potential effects of snowmobile activities (Shea 1973, Alt 1980, Harmata and Oakleaf 1992, Stangl 1994).

Bald eagles in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(1) Destination areas
(2) Primary transportation routes
(3) Scenic driving routes
(4) Groomed motorized routes
(5) Motorized routes
(6) Backcountry motorized areas
(7) Groomed nonmotorized routes
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(10) Downhill sliding (nonmotorized)
(12) Low-snow recreation areas

Management Guidelines

The Bald Eagle Management Plan for the Greater Yellowstone Ecosystem (GYBEWG 1996) established a management goal "to maintain bald eagle populations in the GYA at high levels with high probabilities of persistence and in sufficient numbers to provide significance to the ecosystem, academic research, and readily accessible enjoyment by the recreational and residential public."

Management of bald eagle winter and spring habitat should focus on the presence and abundance of food for eagles that is usually associated with open water, the availability and distribution of foraging perches, the availability of secure night roost sites, and freedom from human harassment (Martell 1992).

Adequate monitoring of bald eagle wintering and nesting populations is fundamental to effective management. Bald eagles may be "urban" or "rural" (GYBEWG 1996) and respond differently to recreation activities. Eagles in the vicinity of high human densities and recreational activities may become habituated to human presence and tolerant of certain human activities. Urban eagles may be exposed to human activities that increase gradually, usually within defined spatial limits, while human activities that rural eagles are exposed to are distributed and moving randomly at varying intensities and often seasonal and abrupt. In some winter recreation areas, eagles will initiate nest building while snowmobile activities are at their highest levels.

The plan (GYBEWG 1996) suggested management guidelines with regard to winter recreation activities, including:

1. Encourage and support research to identify and quantify use and location of seasonal concentrations of bald eagles.
2. Establish buffer zones of 1,300 feet around high-use foraging areas with temporal restrictions from sunset to 10:00 a.m. in areas of high human use or establish site-specific modifications based on research findings.
3. Diurnal perching areas may not always be associated with primary foraging area. If separate, buffer zones of 650 to 1,300 feet around concentrated or high-use perches should be imposed, dependent on exiting vegetative screening. Temporal restrictions should be consistent with seasonal residency. Removal of trees, especially snags greater than 2 feet in diameter that are within 100 horizontal feet or 1,300 feet in elevational rise of greater than 30 degrees from shoreline should be discouraged on private land and prohibited on federal land. Single trees in upland foraging areas devoid of elevated perch sites should be retained.
4. Areas of winter and early spring waterfowl concentrations are important to wintering and migrating eagles. Efforts to enhance existing wetlands and development of new ones should be supported.
5. Strive to maintain visual, temporal, and spatial integrity of the roost site in order to provide for short- and long-term use by bald eagles. Manage critical and vital roost sites temporally and spatially. Areas within 1,300 feet of critical and vital roosts should be closed. Human activity beyond 1,300 feet may be disruptive if above the roost site. In such cases, methods to provide visual screening from the roost site should be explored and based on site inspection and recommendations of biologists. Closures for autumn roosts should extend from 1 October to 1 January, for winter roosts from 15 October to 1 April, for vernal roosts from 1 March to 15 April or determined by actual residency patterns of local eagles. Alternative schemes towards these ends should be encouraged to accommodate human values.
6. Strive for similar protection of secondary sites because they may evolve into critical or vital roosts through succession, fire, wind, or other catastrophe.

Guidelines have been developed in the Bald Eagle Management Plan for the Greater Yellowstone Ecosystem (GYBEWG 1996) and the Montana Bald Eagle Management Plan (MBEWG 1994) to provide management direction for bald eagles where there is little information on areas actually used. The GYBEWG (1996, pages 22–25) defined three zones within bald eagle breeding areas to which these guidelines apply. Zone boundaries should be altered after intensive study of eagle activity and development of site specific management plans. Guidelines and recommendations for the completion of management plans focused on bald eagle habitat or breeding areas.

ZONE I—NEST SITE AREA

The area within a ¼-mile radius of active nest sites should be maintained to protect nest site characteristics, including snags, nest trees, perch trees, roost trees, and vegetative screening. Any disturbances should be eliminated.

1. Human activity should not exceed minimal levels during the period from first occupancy of the nest site until two weeks following fledging (approximately 1 February to 15 August). Minimal human activity levels include essentially no human activity with the following exceptions: (1) existing patterns of ranching and agriculture, (2) nesting surveys and banding by biologist experienced with eagles, and (3) river traffic as defined by the GYBEWG (1996, page 22). Light human activity levels should not be exceeded during the rest of the year. Light human activity levels allow for day use and low impact activities such as boating, fishing, and hiking but at low densities and frequencies. Activities which are excluded include concentrated use associated with recreation centers (*i.e.*, picnic areas, boat landings) and helicopters within 650 yards of the ground.
2. Habitat alterations should be restricted to projects specifically designed for maintaining or enhancing bald eagle habitat and conducted only during September through January.
3. Human activity restrictions for Zone I may be relaxed during years when a nest is not occupied. However, light human activity levels should not be exceeded and land-use patterns should not preclude a return to minimal activity levels.

ZONE II—PRIMARY USE AREA

This zone includes the area ¼- to ½-mile from active nest sites in the breeding area where it is assumed that 75 percent of activities (foraging, loafing, bathing, etc.) of a bald eagle breeding pair occur.

1. Light human activity levels should not be exceeded during the nesting season. Moderate levels should not be exceeded during other times in the year. Moderate human activity include light impact activity levels but intensity of such activities are not limited. A limited number of recreation centers designed to avoid eagle conflicts may be considered. Other activities such as construction should be designed to specifically avoid disturbance. Designing projects or land uses to avoid eagle conflicts requires the sufficient data to formulate a site-specific management plan.
2. Habitat alterations should be carefully designed and regulated to ensure that preferred nesting and foraging habitat are not degraded.
3. Developments that may increase human activity levels and use patterns should not be allowed.

ZONE III—HOME RANGE

This area includes all suitable foraging habitat within 2.5 miles of active nest sites. Areas within the 2.5 mile radius of the nest that do not include potential foraging habitat may be excluded. However, the zone will include a 1,300 foot buffer along foraging habitat where the zone has been reduced.

1. Human activities should not exceed moderate.

2. Projects that could potentially alter the habitat of forage species should be carefully designed to insure availability of prey is not degraded. Adequate design of such projects will require data from site-specific management plans.
3. Terrestrial habitat alterations should ensure important components are maintained. Major habitat alterations should be considered only if site-specific management plans are developed and only if the alterations are compatible with management plans.
4. Permanent developments that are suitable for human occupancy should be avoided.

Other developments that may increase human activity levels should be carefully designed to ensure that objectives would not be exceeded for all three management zones. For example, active nest sites or any nest sites in the breeding area that have been active in the last five years if the active nest has not been identified should be protected.

Elk harvests occur during the fall and winter, and antler collecting occurs during the spring in various areas of the GYA. Gut piles and carcasses resulting from hunting activities provide a valuable foraging resource for wintering, migrating, and breeding bald eagles. Although some activities associated with the late hunt could displace bald eagles, hunting activities are generally completed early in the nesting season and the forage resulting from the harvest is probably more beneficial to bald eagles than the potential for displacement. This is not the case with antler collectors or "horn hunters." Horn hunting activities generally occur during the spring when bald eagles are nesting and are most sensitive to human disturbances. Dispersed activities associated with horn hunting could potentially impact nesting bald eagles if the activities occur around the nest site or in the primary foraging area.

During winter and spring months, many wildlife species congregate at lower elevations. In the GYA, elk and moose are commonly observed along roadways and are periodically observed along designated and groomed snowmobile trails. Natural mortalities and road kill animals provide a winter and spring source of food for bald eagles. However, eagles can, in turn, become road kill victims themselves when foraging on carcasses located next to roads. Carcasses on and along roads should be moved away from the road edge in an effort to protect bald eagles and other scavengers. Similar incidents can occur along railroads where deer, elk, moose, and antelope may concentrate (J. Naderman, Idaho Department of Fish and Game, personal communication). Because a large portion of the GYA lies within the grizzly bear recovery area, road kill and some natural mortality carcasses are removed and are no longer available as a food source in an effort to reduce bear–human conflicts.

LITERATURE CITED

Alt, K. L. 1980. Ecology of breeding bald eagle and osprey in the Grand Teton–Yellowstone National Parks complex. Thesis, Montana State University, Bozeman, Montana, USA.

Anthony, R. G., R. J. Steidl, and K. McGarigal. 1995. Recreation and bald eagles in the Pacific Northwest. Pages 223–241 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreation: coexistence through management and research. Island Press, Washington, D.C., USA.

Buehler, D. A., T. J. Mersmann, J. D. Fraser, and J. K. D. Seegar. 1991. Effects of human activity on bald eagle distribution on northern Chesapeake Bay. Journal of Wildlife Management 55:282–290.

Dzus, E. H., and J. M. Gerrard. 1993. Factors influencing bald eagle densities in northcentral Saskatchewan. Journal of Wildlife Management 57:771–778.

Flath, D. L., R. M. Hazlewood, and A. R. Harmata. 1991. Status of the bald eagle (*Haliaeetus leucocephalus*) in Montana: 1990. Proceedings Montana Academy of Science 51:15–32.

Fraser, J. D., L. D. Frenzel, and J. E. Mathisen. 1985. The impact of human activities on breeding bald eagles in northcentral Minnesota. Journal of Wildlife Management 49:585–592.

Greater Yellowstone Bald Eagle Working Team. 1983. A bald eagle management plan for the Greater Yellowstone Ecosystem. Wyoming Game and Fish Department, Cheyenne, Wyoming, USA.

GYBEWG (Greater Yellowstone Bald Eagle Working Group). 1996. Greater Yellowstone bald eagle management plan: 1995 update. Wyoming Game and Fish Department, Lander, Wyoming, USA.

Grubb, T. C., and R. M. King. 1991. Assessing human disturbance of breeding bald eagles with classification tree models. Journal of Wildlife Management 55:500–511.

Hansen, A. J. 1987. Regulation of bald eagle reproductive rates in southeast Alaska. Ecology 68:1387–1392.

Harmata, A. R., and R. Oakleaf. 1992. Bald eagles in the Greater Yellowstone Ecosystem: an ecological study with emphasis on the Snake River, Wyoming. Wyoming Game and Fish Department, Cheyenne, Wyoming, USA.

Knight, R. L., and S. K. Knight. 1984. Responses of wintering bald eagles to boating activity. Journal of Wildlife Management 48:999–1004.

Knight, R. L., D. P. Anderson, and N. V. Marr. 1991. Responses of an avian scavenging guild to anglers. Biological Conservation 56:195–205.

Martell, M. 1992. Bald eagle winter management guidelines. U.S. Fish and Wildlife Service, Region 3, Minneapolis, Minnesota, USA.

Mathisen, J. E. 1968. Effects of human disturbance on nesting bald eagles. Journal of Wildlife Management 32:1–6.

McGarigal, K., R. G. Anthony, and F. B. Isaacs. 1991. Interactions of humans and bald eagles on the Columbia River Estuary. Wildlife Monograph Number 115.

MBEWG (Montana Bald Eagle Working Group). 1986. Montana bald eagle management plan. U.S. Bureau of Reclamation, Billings, Montana, USA.

———. 1994. Montana bald eagle management plan. U.S. Bureau of Reclamation, Billings, Montana, USA.

Montopoli, G. J., and D. A. Anderson. 1991. A logistic model for the cumulative effects of human intervention on bald eagle habitat. Journal of Wildlife Management 55:290–293.

Shea, D. S. 1973. A management-oriented study of bald eagle concentrations in Glacier National Park. Thesis, University of Montana, Missoula, Montana, USA.

Skagen, S. K. 1980. Behavioral response of wintering bald eagles to human activity on the Skagit River, Washington. Pages 231–241 *in* R. L. Knight, G. T. Allen, M. V. Stalmaster, and C. W. Servheen, editors. Proceedings of the Washington Bald Eagle Symposium. The Nature Conservancy, Seattle, Washington, USA.

Smith, T. J. 1988. The effect of human activities on the distribution and abundance of the Jordan Lake–Falls Lake bald eagles. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA.

Stalmaster, M. V. 1987. The bald eagle. Universe Books, New York, New York, USA.

———, and J. R. Newman. 1978. Behavioral responses of wintering bald eagles to human activity. Journal of Wildlife Management 42:506–513.

Stalmaster, M. V., and J. A. Gessaman. 1984. Ecology energetics and foraging behavior of overwintering bald eagles. Ecological Monograph 54:407–428.

Stangl, J. M. 1994. Effects of monitoring effort and recreation patterns on temporal and spatial activities of breeding bald eagles. Thesis, Montana State University, Bozeman, Montana, USA.

Swenson, J. E., K. L. Alt, and R. L. Eng. 1986. The ecology of the bald eagle in the Greater Yellowstone Ecosystem. Wildlife Monograph Number 95.

USFWS (U.S. Fish and Wildlife Service). 1986. Recovery plan for the Pacific bald eagle. Portland, Oregon, USA.

Walter, H., and K. L. Garrett. 1981. The effects of human activity of wintering bald eagles in the Big Bear Valley, California. Final report to the U.S. Forest Service, Big Bear District, Fawnskin, California, USA.

Whitfield, M. B. 1993. South Fork Snake River bald eagles research project. Final report to the Bureau of Land Management, Idaho Falls District, Idaho Falls, Idaho, USA.

Wright, M., and R. E. Escano. 1986. Montana bald eagle nesting habitat macro-habitat description. U.S. Forest Service, Missoula, Montana, USA.

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EFFECTS OF WINTER RECREATION ON TRUMPETER SWANS

POPULATION STATUS AND TREND

The trumpeter swan (*Cygnus bucci nator*) is a species of special con cern in Idaho (Category A) and Montana, and a Priority 1 species in Wyoming. In March 1989, the Idaho Chapter of the Wildlife Society petitioned the U.S. Fish and Wildlife Service to add the Greater Yellowstone Area (GYA) trumpeter swan population to the threatened species list, but the population was not listed. Concern over the dramatic decline in the GYA trumpeter swan population led to the establishment of the Greater Yellowstone Trumpeter Swan Working Group in 1997.

During the 1800s and early 1900s, commercial trade in swan skins and habitat destruction reduced trumpeter swan populations to a fraction of historic levels. The species neared extinction in the lower 48 states, and isolated areas of protected habitat were critical to the survival of wild trumpeter swans (Banko 1960). The discovery of swans in the Centennial Valley in the 1930s led to the eventual establishment of Red Rocks Lakes National Wildlife Refuge. Management efforts at the refuge, as well as in a few other areas, have helped maintain trumpeter swan numbers in recent decades (Banko 1960, USFWS 1996).

The GYA trumpeter swan population has fluctuated dramatically and declined in recent years to the levels of the 1940s. Areas inside and outside Yellowstone National Park provide habitat for both resident and migratory swans. One theory for the decline is that traditional migration patterns and knowledge of important winter and spring habitats were lost as the species neared extinction. Another theory is that the swan population never migrated out of the GYA in large numbers. As a result, virtually all of the breeding trumpeter swans of Canada and the Greater Yellowstone Area share the same high-elevation winter habitat in the GYA (T. McEneaney, Yellowstone National Park, personal communication).

More than 10,000 swans currently exist in the wild. The Pacific population, representing most of the wild swans, breeds in Alaska and winters along the Pacific Coast from Alaska south to Washington (Ehrlich et al. 1988, Gale 1989). The mid-continental population of approximately 300 birds winters in the GYA. About 55 percent of these birds are year-round residents; the remainder migrate north and spend the summer in Canada (Gale 1989).

Currently, the swan population in the GYA has exhibited declining productivity. In Yellowstone National Park, no cygnets were produced in 1996 or 1997. In 1995, two of eight nest attempts were successful in the park, and six cygnets were produced, but only two fledged. In 1994, five cygnets fledged (NPS 1996; T. McEneaney, Yellowstone National Park, personal communication).

Winter habitat in the GYA is shared by resident and non-resident swans. Winter is a critical time for swans in the GYA as they are are vulnerable to reduced flows of water, heavy ice formation, unusually severe winter weather, disease, and environmental pollution. During the winter of 1988–89, about 100 swans died on the Henrys Fork as a result of ice formation on the river, which was due to low water flow and unusually low temperatures (Gale 1989; T. McEneaney, Yellowstone National Park, personal communication).

LIFE HISTORY

Trumpeter swans begin breeding between 3 and 6 years of age (most commonly at 4 or 5 years). They return to their breeding territories between February and late May. Most pairs remain together year-round and bond for life. The female normally lays between 4–6 eggs and incubates them for 33–37 days. The young hatch around late June and are precocial (they are mobile, downy, follow parents, and find their own food). The time from hatching to fledging ranges from 91–119 days. Cygnets remain with their parents through their first winter (Ehrlich et al. 1989, Gale 1989).

Trumpeter swan winter habitat is associated with open water, especially along the Henrys Fork River and the thermally influenced waters of Yellowstone National Park. Winter habitat must provide extensive areas of ice-free open water where aquatic plants are available (Gale 1989, USFWS 1996, Banko 1960).

NESTING HABITAT

Breeding habitat is usually freshwater, especially the emergent vegetation on the margin of ponds, marshes, and lakes; however, brackish waters and slow-moving oxbows may be used. Nests are surrounded by water and built of aquatic and emergent vegetation, down, and feathers. Nests are often built on muskrat houses, beaver lodges, or small islands. Trumpeters generally use the same nest site for several years (Banko 1960).

Breeding territory in the GYA ranges from 25–37 acres and generally coincides with the size of the nesting lake. At Red Rocks Lakes National Wildlife Refuge in Montana, breeding territories average 32 acres. Breeding pairs exclude other trumpeter swans from their territories during the nesting and brooding period (USFWS 1996, Reel et al. 1989).

HUMAN ACTIVITIES

Swan tolerance for people varies by season and situation. Swans seem to be more tolerant of humans during the winter months, but display reduced tolerance as spring approaches, and they are preparing to migrate or breed (T. McEneaney, Yellowstone National Park, personal communication; Shea 1979). Observations by Shea (1979) indicated that swans on the Madison River showed more tolerance to winter recreationists than did swans on the Yellowstone River. Swans wintered on the Madison River within 55 yards of the road, which had heavy snowmobile traffic. Swans often retreated when visitors stopped, but continued to feed. Swans on the Yellowstone River generally reacted to recreationists by swimming farther out from shore (Shea 1979). Swans at Harriman State Park in Idaho had a more pronounced reaction to human disturbance; when approached by a person on skis or snowmobile, swans broke into flight, often moving several miles to another stretch of the river (Shea 1979).

POTENTIAL EFFECTS

Swan conservation efforts in the GYA focus on ensuring adequate stream flows and protecting and enhancing nesting and wintering habitat. Nesting and brood-rearing seasons are critical times for swan survival and production. Disturbance by humans can have negative effects on trumpeter swans and other waterfowl. Henson and Grant (1991) note that:

> . . . disturbance can affect productivity in a number of ways including nest abandonment, egg mortality due to exposure, increased predation of eggs and hatchlings, depressed feeding rates on wintering and staging grounds, and avoidance of otherwise suitable habitat.

In winter, problems occasionally arise when recreationists approach swans too closely. This kind of activity can lead swans to become habituated to humans, which may make them more prone to predation or roadkill. It can also lead to flushing swans from open water, resulting in increased energy requirements and a loss of energy reserves essential to surviving the winter and hatching and rearing young. The effect is exacerbated by the number of times a swan experiences disturbances.

Aune (1981) found that swans appeared to become habituated to moving snowmobiles, but that they fly or swim away upon approach by foot or ski or when a snowmobiler stopped. Aune noted that, in general, animals function best in a predictable environment. Groomed routes, both for snowmobilers and skiers, create a more predictable environment.

High cygnet mortality prior to fledging can to be related to the poor condition of nesting females following severe winters and/or late, cold springs. However, Maj (1983) found that mortality is more site- or pair-specific and not entirely related to the nutritional status of the laying female. Maj also noted that 130–190 days are required to lay an average clutch of five eggs, incubate the eggs to full term, and raise the cygnets to fledging. Limitations to breeding time may be an important factor in the GYA where only approximately 90 frost-free days occur each year. Drought conditions are also an important factor in cygnet mortality.

Trumpeter swans in the GYA are particularly affected by human use of the following Potential Opportunity Areas as well as any opportunity area that has open water:

(1) Destination areas
(4) Groomed motorized routes
(5) Motorized routes
(6) Backcountry motorized areas
(7) Groomed nonmotorized routes
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(12) Low-snow recreation area

MANAGEMENT GUIDELINES

- Designating snowmobile and ski trails away from open waters used as winter habitat by swans can mitigate winter recreational impacts on the birds.
- Special restrictions may need to be implemented on open-water snowmobiling in areas that swans routinely use for feeding. These measures would reduce the energetic expenditures resulting from disturbance.
- Some concern has been raised about the effects of snowmobile noise on swans. At this time, no information is available on this subject.

LITERATURE CITED

Aune, K. 1981. Impacts of winter recreationists on wildlife in a portion of Yellowstone National Park, Wyoming. Thesis, Montana State University, Bozeman, Montana, USA.

Banko, W. E. 1960. The trumpeter swan. University of Nebraska Press, Lincoln, Nebraska, USA.

Ehrlich, P., D. Dobkin, and D. Wheye. 1988. The birder's handbook: a field guide to the natural history of North American birds. Simon & Schuster, New York, New York, USA.

Gale, R. S. 1989. Pages 59–60 *in* T. W. Clark, A. H. Harvey, R. D. Dorn, D. L. Genter, and C. Groves, editors. Rare, sensitive, and threatened species of the Greater Yellowstone Ecosystem. Northern Rockies Conservation Cooperative, Montana Natural Heritage Program, The Nature Conservancy, and Mountain West Environmental Services, Jackson, Wyoming, USA.

Hensen, P., and T. A. Grant. 1991. The effects of human disturbance on trumpeter swan breeding behavior. Wildlife Society Bulletin 19:248–257.

Maj. M. E. 1983. Analysis of trumpeter swan habitat on the Targhee National Forest of Idaho and Wyoming. Thesis, Montana State University, Bozeman, Montana, USA.

NPS (National Park Service). 1996. Yellowstone Center for Resources 1995 Annual Report. Yellowstone National Park, Wyoming, USA.

Reel, S., L. Shassberber, and W. Reudiger. 1989. Caring for our natural community. Region 1 threatened, endangered & sensitive species program. U.S. Forest Service, Northern Region, Missoula, Montana, USA.

Shea. R. 1979. The ecology of the trumpeter swan in Yellowstone National Park and vicinity. Thesis, University of Montana, Missoula, Montana, USA.

USFWS (U.S. Fish and Wildlife Service). 1996. Trumpeter swan survey of the Rocky Mountain population/U.S. flocks. Red Rock Lakes National Wildlife Refuge, Lakeview, Montana, USA.

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HABITAT

Photo courtesy of the National Park Service

EFFECTS OF WINTER RECREATION ON VEGETATION

Snowmobile, snowcoach, cross-country and telemark ski, snowshoe, and dog-sled activities occur throughout the winter and spring in the Greater Yellowstone Area (GYA). These activities occur on designated and/or groomed trails or as dispersed activities. Snowmobile activities often occur on constructed dirt and paved roadbeds. However, damage to vegetation has been observed in the GYA that is caused by winter recreational activities that occur off-trail. For example, branches of willows (*Salix* spp.) and sagebrush (*Artemisia* spp.) have been broken, and leaders have been removed from conifers.

POTENTIAL EFFECTS

There is little information available describing the ecological effects of snowmobiling and other winter recreational activities on vegetation. Research cited was completed in the 1970s and focused on assessing the impacts of snowmobile use on vegetation and snow characteristics in Minnesota and Canada.

SNOW COMPACTION

Snowmobile activities create trails as the vehicle compacts the snow. Other winter recreation activities also have the potential to increase snow compaction depending on the intensity of the activities. One traverse over undisturbed snow cover can affect the physical environment as well as damage plants (Wanek 1971). Compacted snow was calculated to have two to three times more density than uncompacted snow in Canada. Thermal conductivity of compacted snow was 11.7 times greater than uncompacted snow (Neumann and Merriam 1972).

SOIL TEMPERATURES

Soil temperature can also be affected by snowmobile compaction of snow. Wanek (1971, 1973) and Wanek and Schumacher (1975) observed that surface soil temperature under compacted snow was erratic and constantly lower than under uncompacted snow. Soils in the areas where snowmobiles traveled thawed later than where snowmobiles did not travel (Wanek and Schumacher 1975). This resulted in subsequent deep freezing that could affect the survival of many vegetative species. Wanek and Schumacher (1975) found that a large number of perennial herbs having subterranean organisms were subject to intracellular ice crystals which caused tissue dehydration. Soil bacteria, essential to the plant food cycle, were reduced 100-fold beneath a snowmobile track (Wanek 1971, 1973).

VEGETATION

Snowmobile activities damage vegetation on and along trails and in dispersed sites. The most commonly observed effect from snowmobiles was the physical damage to shrubs, saplings, and other vegetation (Neumann and Merriam 1972, Wanek 1971, Wanek and Schumacher 1975). Neumann and Merriam (1972) observed that compacted snow conditions caused twigs and branches to bend sharply and break. Stems that were more pliable bent and sprang back although the snowmobile track often removed bark from the stems' upper surfaces. Neumann and Merriam (1972) found that rigid woody stems up to one inch in diameter were very susceptible to damage. Stems were snapped off in surface-packed or crusted snow.

Snowmobiles often run over trees and shrubs tearing the bark, ripping off branches, or topping trees. In some trembling aspen (*Populus tremuloides*) areas, populations increased after snowmobiles disturbance. Deciduous trees that sucker may increase at first but then may decline if snowmobile activities remove the sucker shoots for several successive years (Wanek and Schumacher 1975). Studies (Neumann and Merriam 1972; Wanek 1971, 1973) indicated that conifers differed in tolerance of snowmobile traffic, and that pine species (*e.g.*, *Pinus contorta*) were less susceptible to damage than spruce species (*e.g., Picea glauca*). Wanek and Schumacher (1975) found that young conifers were severely damaged by minimal snowmobile traffic. Depth of snow accumulation was the greatest factor contributing to snowmobile damage to conifers. Deeper snow tended to protect some species and age classes.

Herbaceous and woody plants exhibited varying responses to snowmobile activities. Most species were vulnerable to physical damage by snowmobiles. Twigs and branches of shrubby cinquefoil (*Potentilla fruticosa*) were broken more readily than aspen and buffalo berry (*Elaeagnus canadensis*). Some species increased while others decreased in number. Masyk (1973) found that productivity of grasses may be reduced in areas of snowmobile use. Wanek and Schumacher (1975) found that snowmobile activities set back the growth of some fast growing trees that normally would shade out some shrub species. Therefore, heliophytic shrubs proliferated.

In bog communities, snowmobile activities can result in frost penetrating more deeply, thereby delaying the spring thaw. Herbs and shrubs in these areas may exhibit population declines. Bog shrubs are highly susceptible to physical damage (Wanek 1973).

Early spring growth of some species may be retarded or may not grow under a snowmobile trail. This could potentially reduce the diversity of plants species available and/or reduce the quantity of available forage and the duration of forage availability for wildlife during the spring.

EROSION

Snowmobile activities may indirectly contribute to erosion of trails and steep slopes. If steep slopes are intensively used, snow may be removed and the ground surface exposed to extreme weather conditions and increased erosion by continued snowmobile traffic. The same results could occur when snowmobiles use exposed southern exposures. Because compacted snow generally takes longer to melt, trails are often wet and soft when the surrounding areas are dry. Consequently, these trails are susceptible to damage by other users during the spring (Masyk 1973).

In the GYA, the Potential Opportunity Areas in which vegetation is most affected include:

- (4) Groomed motorized routes
- (5) Motorized routes
- (6) Backcountry motorized areas
- (7) Groomed nonmotorized routes
- (8) Nonmotorized routes
- (9) Backcountry nonmotorized areas
- (10) Downhill sliding (nonmotorized)

MANAGEMENT GUIDELINES

Adverse effects to vegetation are the result of cumulative factors. The impact of snowmobile activities on the physical environment varies with winter severity, the depth of snow accumulation, the intensity of snowmobile traffic, and the susceptibility of the organism to injury (Wanek 1973). Activities occurring on roadbeds and (most likely) trails are probably having little affect on vegetation as the areas are already compacted or disturbed. Effects of snowmobile activities on off-trail vegetation should be assessed at a landscape level.

Management or restriction of snowmobile activities should be considered in areas where forest regeneration is being encouraged as deformation of growth patterns was observed in conifers where leaders had been removed by snowmobile activities (Neumann and Merriam 1972). Management or restrictions should also be considered in fragile or unique communities, such as riparian and wetland habitats, thermal areas, sensitive plant species habitat, and areas of important wildlife habitat, in order to preserve these habitats.

LITERATURE CITED

Masyk, W. J. 1973. Snowmobile, a recreation technology in Banff National Park: environmental impact and decision-making. University of Calgary and the University of Western Ontario, London, Ontario, Canada.

Neumann, P. W., and H. G. Merriam. 1972. Ecological effects of snowmobiles. Canadian Field Naturalist 86:207–212.

Wanek, W. J. 1971. Snowmobiling impact on vegetation, temperatures and soil microbes. Pages 117–130 *in* Snowmobile and off-road vehicle research symposium proceedings. Technical Report Number 8. Department of Park and Recreation Resources, Michigan State University, Lansing, Michigan, USA.

———. 1973. Ecological impact of snowmobiling in Northern Minnesota. Pages 57–76 *in* Snowmobile and off-road vehicle research symposium proceedings. Technical Report Number 9. Department of Park and Recreation Resources, Michigan State University, Lansing, Michigan, USA.

———, and L. H. Schumacher. 1975. A continuing study of the ecological impact of snowmobiling in northern Minnesota. Final report for 1974–75. State College, Bemidji, Minnesota, USA.

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ISSUES

Photo courtesy of the National Park Service

EFFECTS OF DEVELOPMENT ON WILDLIFE

Increasing human development has a variety of impacts on wildlife and their habitats. The effects of development may act as additional adverse impacts to wildlife populations already affected by human activity. This may be important during winter when many wildlife populations are already nutritionally and energetically stressed.

The term "development" is most frequently used in reference to new home-building: subdivisions, ranchettes, and second homes. While this activity is possibly the most important factor affecting western wildlife, other types of development impact wildlife and habitats as well. For example, conversion of former wildlife habitat to agricultural use or livestock grazing land where wildlife is excluded and the construction of new roads or the expansion of existing road networks that create unsuitable habitats for wildlife are both types of development that may have important consequences for wildlife. Development, therefore, can be defined as any human activity that permanently reduces or removes habitat that is currently available to wildlife.

DEVELOPMENT IN THE GREATER YELLOWSTONE ECOSYSTEM

Although more than 80 percent of the Greater Yellowstone Area (GYA) is in public ownership, the approximately 20 percent of the area that is in private ownership (about 3 million acres) contains some of the area's most important wildlife habitats. These lands include ungulate winter ranges, riparian areas, and wetlands (Harting and Glick 1994). Since 1990, the region has experienced an overall growth rate of 12 percent, with some counties experiencing growth rates as high as 50 percent (Glick et al. 1991). As a result, home-building on rural private lands has increased tremendously (Glick et al. 1991), and nearly one-third of the region's private acres have been subdivided (Rasker and Glick 1994). As more people settle in the area, existing roads are increasingly unable to accommodate the larger volumes of traffic, and roads are often widened or new roads are built to link areas of development and use (Glick et al. 1998). The region's increasing population also contributes to increasing human use of the region's natural areas. For example, an estimated 25 percent of all visitors to Yellowstone National Park in 1990 were residents of the surrounding three states (National Park Service 1998).

GENERAL IMPACTS OF DEVELOPMENT ON WILDLIFE

DIRECT MORTALITY

Many human uses of developed landscapes are incompatible with wildlife use or presence and may result in direct mortality of wildlife that attempt to occupy those areas. Ungulates attempting to use historic winter range that has been converted to grazing land or agricultural use may not be tolerated because they compete with livestock for forage or cause damage to crops. Consequently, hunting seasons and/or areas may be designed to eliminate wildlife from those areas, or wildlife may be killed in special management actions. Large carnivores, such as bears and wolves, are generally not tolerated in proximity to areas of human habitation or use. Collisions with vehicles may also be a significant source of mortality for some wildlife populations. Between 1989 and 1995, an average of 117 wild animals were killed annually in vehicle collisions in Yellowstone National Park (Gunther et al. 1997). Severe winters may increase the number of road kills when wildlife seek lower elevation, low-snow areas, which are where roads tend to be built. Many animals also use roads and groomed trails as travel corridors when snow becomes deep and restricts movement. During the last ten years more than a dozen animals, including bison, coyotes, elk, and moose, have been killed in collisions with snowmobiles in Yellowstone National Park (M. Biel, Yellowstone National Park, personal communication).

Reduction or Elimination of Winter Range

Most ungulate species in the Rocky Mountain West rely on distinct summer and winter ranges, taking advantage of seasonally available forage at higher elevations during the summer and returning to areas of lower snow accumulation during the winter where there is greater access to forage. These low-elevation winter ranges, however, tend also to be favored by humans for settlement, agriculture, and road-building (Glick et al. 1998). Human occupation of winter home ranges may lead to decreased reproduction or increased mortality of ungulates that traditionally use those areas by decreasing the amount or quality of forage or by increasing disturbance levels (Mackie and Pac 1980, Houston 1982, Smith and Robbins 1994). Because ungulates tend to concentrate in areas of limited size during the winter, loss or degradation of even small portions of winter range have consequences far greater than loss of similarly sized portions of summer range (Mackie and Pac 1980).

Fragmentation of Habitats and Populations

Development frequently has the effect of fragmenting formerly large or widespread populations into smaller sub-populations isolated from one another to varying degrees. Fragmentation may also mean that connections to supplemental habitats or seasonal ranges are degraded or lost (Wilcove et al. 1986, Dunning et al. 1992). The ability of individuals to recolonize areas or supplement declining populations may be lost when habitat connections between sub-populations are degraded or severed (Wilcove et al. 1986). Because of these factors, populations in isolated natural areas tend to be small (Wilcove et al. 1986, Dunning et al. 1992). Small population size and lack of habitat options generally result in a lowered ability to withstand disturbance or natural environmental fluctuations and can result in local extinction of wildlife populations (Wilcove et al. 1986).

Disturbance

Increasing numbers of humans present in the region have meant an increasing amount of human activity in areas used by wildlife. Human activity may prevent some wildlife species from taking advantage of foraging opportunities within their home ranges, even where habitats remain intact. Green (1994), for example, found that roads and traffic in Yellowstone may diminish or prevent bear use of some winter-killed ungulate carcasses. Disturbance that occurs in winter or other periods of energetic stress can be of particular concern. During the winter, many animals reduce their activity, and therefore energy expenditure, to compensate for reduced energy intake, a result of limited quantity and quality of available forage (Telfer and Kelsall 1984). Aune (1981) found that elk, bison, mule deer, and moose in Yellowstone National Park developed crepuscular activity patterns and showed altered patterns of movement and habitat use in response to winter recreationists. Behavioral and physiological responses to continuing harassment in the form of noise or certain types of human presence can shift an animal's energy balance so that more is expended than is taken in, which results in decreased survival or reproduction success (Anderson 1995).

OTHER IMPACTS

In addition to the examples listed above, development can have a variety of other impacts on wildlife. Subdivisions, agricultural areas, clearcuts, or roads can block migration or movement routes, resulting in the inability of animals to reach important habitat components such as breeding or nesting areas, seasonally available forage, or refuges from predation or disturbance (Wilcove et al. 1986, Dunning et al. 1992). Development can alter habitats making them more favorable for generalist species that out-compete specialists in their former habitats. White-tailed deer, for example, appear to be replacing mule deer near developed areas in the Gallatin Valley (Vogel 1989). Although attempts have been made in recent years to restore the role of fire in natural areas, the presence of nearby human developments means that fire suppression will continue on large portions of many protected areas. Long-term fire suppression leads to changes in vegetation, which may impact wildlife in diverse ways (Houston 1982). Ground disturbance by humans has increased the presence and distribution of various species of exotic vegetation that may out-compete important native forage species. Cheatgrass (*Bromus tectorum*), for example, has invaded large portions of western rangelands. While this species greens early and may be of some spring forage value to ungulates, it may ultimately reduce the availability of winter forage by out-competing other, later maturing species (Houston 1982).

IMPACTS TO INDIVIDUAL SPECIES

ELK

Humans are increasingly occupying elk winter range in the GYA. In the Jackson Hole area in the early part of this century, human occupation of elk winter range contributed to the death by starvation of thousands of elk in the valley (Anderson 1958, Robbins et al. 1982). Actions taken to mitigate for human usurpation of winter range, however, have created other problems and led to complex management issues requiring often controversial solutions.

In 1912 Congress set aside a portion of the remaining valley bottom as the National Elk Refuge, and in the 1950s winter feeding of elk on the refuge and on other state-run feedgrounds in Wyoming became policy (Anderson 1958). Because the available winter range is restricted in size and the feeding program was designed to maintain a relatively high elk population, a sometimes controversial hunting program designed to control the size of the elk population was necessary (Smith and Robbins 1994). Maintaining a large number of elk in a geographically restricted area has also contributed to the continued presence of brucellosis in the herd (Thorne et al. 1991). Brucellosis in cattle has been the subject of an intensive state and federal eradication program, and the presence of the *Brucella abortus* bacteria in wildlife in the GYA has been the subject of much controversy in recent years, complicating management of both bison and elk.

Elk in the northern portion of the GYA do not present such perplexing management problems, but are nevertheless faced with decreasing availability of winter range. Historical accounts indicate that large numbers of elk wintered in the Yellowstone River valley north of Gardiner, Montana, and summered in the mountain ranges north of the park (Houston 1982). Settlement and agricultural development in the valley bottom have reduced the number of elk that are year-round residents in this area to slightly more than 1,000 animals.

These animals winter along the margins of the valley (Houston 1982). In recent years, range expansion of the northern Yellowstone elk herd during the winter has been of some concern to wildlife and land managers (T. Lemke, Montana Fish, Wildlife and Parks, personal communication) and private landowners. During some winters, elk use both public and private lands designated for summer livestock grazing, lessening the forage available to cattle. In severe winters, elk often depredate winter hay stores on private lands in the valley bottom. Any factors decreasing the quality or availability of the winter range on public lands and protected areas will only increase the magnitude of these problems and increase pressures on the elk population.

BISON

Bison management in the GYA has been the subject of major controversy, largely because both the Yellowstone and the Jackson bison herds have been exposed to brucellosis. Brucellosis is a disease of cattle that has been the subject of an intensive state and federal eradication program since the 1930s. Because neither Yellowstone nor Grand Teton national parks encompass a complete ecosystem for most ungulates, including bison (Keiter 1991), animals migrate out of the parks in the winter. Historically, during severe winters, Yellowstone bison probably migrated to lower elevation winter ranges in the Yellowstone River valley north of the park (Meagher 1973) and, possibly, also to winter ranges in the Madison Valley. The bison population in Yellowstone was driven to near-extinction by the beginning of the twentieth century (Meagher 1973), and during the subsequent decades when the population was recovering and heavily managed, most of the historic winter range outside the park boundary was settled and developed by humans. Much of the land adjacent to the parks is used for cattle grazing and ranching for all or part of the year. Because of the concern that infected or exposed bison could transmit brucellosis to cattle (Thorne et al. 1991) and because bison may compete with cattle for forage or destroy fences or other private property, a very complex and controversial set of management plans and policies have evolved for Yellowstone's bison.

Bison from Grand Teton National Park migrate to the National Elk Refuge and take advantage of the winter feed provided for elk. Both elk and bison on the refuge have been exposed to brucellosis, and concerns exist regarding potential contact between bison and nearby cattle (Thorne et al. 1991). The result, as in Yellowstone, is a controversial management scenario that continues to be the subject of debate and discussion.

MULE DEER

Mule deer populations in portions of the GYA have declined dramatically in recent years, and human development on winter range may be a contributing factor. Mule deer numbers declined as subdivisions and human activity increased on historic winter range northeast of Bozeman, Montana (Mackie and Pac 1980, Vogel 1989). Individual mule deer, particularly adult does, exhibit a high degree of fidelity to the same seasonal home ranges (Garrott et al. 1987, Mackie and Pac 1980). Because of this, it has been estimated that loss of one square mile of primary winter range along the foothills of the Bridger Range could result in loss of up to 30 percent of the southern Bridger Range mule deer population (Mackie and Pac 1980). Disturbance associated with increased housing development may cause deer to become more nocturnal (Vogel 1989, Dasmann and Taber 1956). This shift in activity pattern could increase energetic demands on deer and other animals during winter when they are nutritionally and energetically stressed by causing them to forage during colder and more severe nighttime weather (Aune 1981, Vogel 1989).

Impacts may differ between migratory and resident herds. Nicholson et al. (1997) found that migratory mule deer are much more vulnerable to human disturbance than are resident animals. This may have serious implications for other migratory ungulates as well, including elk that migrate in and out of Yellowstone and Grand Teton national parks.

PRONGHORN

The northern Yellowstone pronghorn herd, at present numbering roughly 250 animals, is a remnant of a population that historically occupied the Yellowstone River Valley between Gardiner and Livingston, Montana (Barmore 1980). This herd may have been contiguous with pronghorn populations farther east in Montana. Pronghorn were eliminated south of Livingston prior to 1920 (Skinner 1922, Nelson 1925). Consequently, the Yellowstone pronghorn population is isolated. It is estimated that the herd has approximately 18 percent chance of extinction in the next 100 years (Goodman 1996) because of its small size and complete isolation from other pronghorn populations. Currently, pronghorn in Yellowstone have limited access to private lands north of the park boundary and, therefore, little buffer against severe conditions that occur at times within the park. Severely limited winter range may have contributed to a recent decline in numbers in this population.

The Jackson Hole segment of the Sublette Antelope Herd may be at risk from development. This population segment exhibits seasonal migrations from Grand Teton National Park south to Interstate 80 near Rock Springs, Wyoming. Oil and gas development on critical winter ranges of these antelope, coupled with increasing pressure on naturally restricted migration corridors, threatens such movement (Doug McWhirter, personal communication).

MID-SIZED CARNIVORES (MARTEN, LYNX, AND WOLVERINE)

Mid-sized carnivores, such as marten, lynx and wolverine, are particularly vulnerable to the effects of habitat fragmentation. The current presence and distribution of lynx and wolverine in the GYA is likely influenced by development and habitat fragmentation that is the result of logging and road-building. The patches of habitat remaining may not be of sufficient size to guarantee an adequate prey base to sustain populations of these species (Buskirk and Ruggiero 1994, Lyon et al. 1994). The quality of smaller habitat patches may also be degraded as a result of influences from edge species and other disturbances occurring at or near patch boundaries (Wilcove et al. 1986).

Marten, and to some extent lynx, require significant amounts of late successional stage (old-growth) forest components in their home ranges (Buskirk and Ruggiero 1994, Lyon et al. 1994). The appearance of early successional stage vegetation and structure in a mature forest that is a result of logging or subdivisions combined with easier access via summer roads or groomed snowmobile trails may increase the number of generalist predators, such as bobcats and coyotes, that compete with marten, lynx, and wolverine (Lyon et al. 1994). Dispersal and migration of marten may be largely dependent on the presence of heavily vegetated riparian areas or connected patches of mature forest (Lyon et al. 1994). Development of any kind may alter or remove these corridors, isolating populations, decreasing stability of the prey base (Buskirk and Ruggiero 1994), and increasing vulnerability to environmental pressures. Disturbance by humans is of concern during winter, when small prey that is utilized by martens may be less available because of snowcover (Buskirk and Ruggiero 1994). Woody debris allows marten to access prey beneath the snow surface (Buskirk and Ruggiero 1994), and its loss along with the compaction of snow by vehicles may have negative impacts on marten populations by decreasing available food.

LARGE CARNIVORES

Grizzly bears in the GYA are effectively isolated from other populations. Maintenance of a stable or increasing bear population depends solely on reproduction by resident females (Knight and Eberhardt 1985). Most grizzly bear deaths in the GYA between 1973 and 1985 were human caused (both legal and illegal) and were clustered around gateway communities or other developments near Yellowstone National Park. Various attractants such as garbage, orchards, and outfitter camps tend to draw bears into conflict situations with humans, frequently resulting in bear mortality (Herrero 1985, Knight et al. 1988). Developments can function as population sinks for bears and other animals, potentially creating a drain on already stressed populations.

Humans are responsible for most mortalities experienced by the newly reintroduced wolves in the GYA (Phillips and Smith 1997). Deaths occurred by collisions with vehicles, poaching, or management removals following wolf depredation on domestic livestock. Development on the borders of Yellowstone puts wolves in jeopardy if they travel outside of protected areas.

Factors that stress ungulate populations, and thus increase their vulnerability to predation or other types of mortality, may benefit large carnivores and scavenger species in the short-term. However, if such factors lead to a long-term reduction of the ungulate populations, carnivore and scavenger species may be adversely affected through a reduction in the total amount of prey or carrion biomass available to them.

OTHER SPECIES

Little is known about the several owl species inhabiting this region (Holt and Hillis 1987), but owls may be particularly vulnerable to disturbance during winter when prey species are less vulnerable due to snowcover. Guth (1978) found that bird density and diversity increased in developed sites, but that the species present represented a greater percentage of common and widespread species; several rare forest species were absent. Amphibians, reptiles, small mammals, and fish are likely to be affected indirectly and more subtly by development and recreation than large mammal species (Cole and Landres 1995). Impacts to these smaller species, however, may have long-term impacts to overall wildlife community structure and function by altering prey base, plant community dynamics, and animal distribution (Gutzwiller 1995).

MANAGEMENT GUIDELINES

It has been stated that a critical role of parks and other protected natural areas is to compensate or correct for the influence of modern man on ecosystem processes (Houston 1982). Few wildlife populations in the GYA are restricted entirely to protected areas (Keiter 1991), however, and protected areas are also subject to pressures accompanying development. Many effects of development, such as removing winter range, blocking migration routes, disturbance caused by human activity, and reducing quantity or quality of forage species, carry particular impacts during the winter when animals are nutritionally and energetically stressed. In view of these observations, the following recommendations may help to reduce or mitigate the impacts of development on wildlife:

- Minimize future development and, where possible, reduce current levels of development and their concomitant impacts in natural and protected areas.
- Place any necessary new developments within or immediately adjacent to existing developments so that human impacts are clustered, allowing larger portions of relatively pristine habitat to remain intact. The location of future and existing activities and developments should be carefully considered to avoid disturbing or removing important habitat components.
- Intrusive, noisy, or otherwise potentially disturbance-causing human activities should be avoided during the times of year when wildlife populations are already under severe environmental and/or physiological stress. Winter is a critical stress period for ungulates, and birthing/nesting time is critical for a wide variety of species.
- Cooperation among adjoining land management agencies and with landowners adjacent to protected areas should be strengthened so that habitats spanning more than one jurisdiction are managed or conserved as intact systems.
- Where possible, ungulate winter range should be protected or access acquired for wildlife to mitigate for existing development levels.
- Research and monitoring programs on a wide variety of species are vital to accomplishing most of the recommendations above. Information on seasonal habitats, migration routes, nesting or birthing sites and areas, and timing of animal activities are necessary in order to avoid significant impacts of development on wildlife populations.

Literature Cited

Anderson, C. C. 1958. The elk of Jackson Hole: a review of Jackson elk studies. Wyoming Game and Fish Commission Bulletin Number 10. Cheyenne, Wyoming, USA.

Anderson, S. H. 1995. Recreational disturbance and wildlife populations. Pages 157–168 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreation: coexistence through management and research. Island Press, Washington, D.C., USA.

Aune, K. E. 1981. Impact of winter recreationists on wildlife in a portion of Yellowstone National Park, Wyoming. Thesis, Montana State University, Bozeman, Montana, USA.

Barmore, W. J. 1980. Population characteristics and habitat relationships of six ungulates in northern Yellowstone Park. Final report. National Park Service, Yellowstone National Park, Wyoming, USA.

Buskirk, S. W., and L. F. Ruggiero. 1994. American marten. Pages 7–37 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski, editors. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the western United States. General Technical Report RM-254. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Cole, D. N., and P. B. Landres. 1995. Indirect effects of recreationists on wildlife. Pages 183–202 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreation: coexistence through management and research. Island Press, Washington, D.C., USA.

Dasmann, R. F., and R. D. Taber. 1956. Behavior of Columbian black-tailed deer with reference to population ecology. Journal of Mammalogy 37:143–164.

Dunning, J. B., B. J. Danielson, and H. R. Pulliam. 1992. Ecological processes that affect populations in complex landscapes. Oikos 65(1):169–175.

Garrott, R. A., G. C. White, R. M. Bartmann, L. H. Carpenter, and A. W. Alldredge. 1987. Movements of female mule deer in northwest Colorado. Journal of Wildlife Management 51:634–643.

Glick, D., M. Carr, and B. Harting. 1991. An environmental profile of the greater Yellowstone ecosystem. Greater Yellowstone Coalition, Bozeman, Montana, USA.

———, D. Cowan, R. Bonnie, D. Wilcove, C. Williams, D. Dellasala, and S. Primm. 1998. Incentives for conserving open lands in greater Yellowstone. Greater Yellowstone Coalition, Bozeman, Montana, USA.

Goodman, D. 1996. Viability analysis of the pronghorn population wintering near Gardiner, Montana. Unpublished report, Montana State University, Bozeman, Montana, USA.

Green, G. I. 1994. Use of spring carrion by bears in Yellowstone National Park. Thesis, University of Idaho, Moscow, Idaho, USA.

Gunther, K. G., M. Biel, H. L. Robison, and H. Zachary. 1997. Administrative annual report for calendar year 1996. Bear Management Office, Yellowstone National Park, Wyoming, USA.

Guth, R. W. 1978. Forest and campground bird communities of Peninsula State Park, Wisconsin. Passenger Pigeon 40:489–493.

Gutzwiller, K. J. 1995. Recreational disturbance and wildlife communities. Pages 169–181 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreation: coexistence through management and research. Island Press, Washington, D.C., USA.

Harting, B., and D. Glick. 1994. Sustaining greater Yellowstone, a blueprint for the future. Greater Yellowstone Coalition, Bozeman, Montana, USA.

Herrero, S. 1985. Bear attacks: their causes and avoidance. Nick Lyons Books, New York, New York, USA.

Holt, D. W., and J. M. Hillis. 1987. Current status and habitat associations of forest owls in western Montana. Proceedings of a Symposium on Biology and Conservation of Northern Forest Owls. General Technical Report Number RM-142. U.S. Forest Service, Rocky Mountain Range and Forest Experiment Station, Fort Collins, Colorado, USA.

Houston, D. B. 1982. The northern Yellowstone elk. Macmillan, New York, New York, USA.

Keiter, R. B. 1991. An introduction to the ecosystem management debate. Pages 3–18 *in* R. B. Keiter and M. S. Boyce, editors. The greater Yellowstone ecosystem: redefining America's wilderness heritage. Yale University Press, New Haven, Connecticut, USA.

Knight, R. R., and L. L. Eberhardt. 1985. Population dynamics of the Yellowstone grizzly bear. Ecology 66:323–334.

Knight, R. R., B. M. Blanchard, and L. L. Eberhardt. 1988. Mortality patterns and population sinks for Yellowstone grizzly bears, 1973–1985. Wildlife Society Bulletin 16:121–125.

Lyon, L. J., K. B. Aubry, W. J. Zielinski, S. W. Buskirk, and L. F. Ruggiero. 1994. The scientific basis for conserving forest carnivores: considerations for management. Pages 128–137 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski, editors. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the western United States. General Technical Report RM-254. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Mackie. R. J., and D. F. Pac. 1980. Deer and subdivisions in the Bridger Mountains, Montana. Pages 517–526 *in* Proceedings of the 60th annual conference of the Western Association of Fish and Wildlife Agencies, Kalispell, Montana, USA.

Meagher, M. M. 1973. The bison of Yellowstone National Park. National Park Service, Scientific Monograph Number 1, Yellowstone National Park, Wyoming, USA.

Nelson, E. W. 1925. Status of the pronghorn antelope, 1922–24. U.S. Forest Service Bulletin Number 1346.

Nicholson, M. C., R. T. Bowyer, and J. G. Kie. 1997. Habitat selection and survival of mule deer: tradeoffs associated with migration. Journal of Mammalogy 78:483–504.

NPS (National Park Service). 1998. Draft Environmental Impact Statement for the Interagency Bison Management Plan for the State of Montana and Yellowstone National Park. Publication D-655. May 1998.

Phillips, M. K., and D. W. Smith. 1997. Yellowstone wolf project biennial report: 1995 and 1996. National Park Service, Yellowstone Center for Resources Report Number YCR-NR-97-4, Yellowstone National Park, Wyoming, USA.

Rasker, R., and D. Glick. 1994. Footloose entrepreneurs: pioneers of the new west? Illahee? Journal for the Northwestern Environment 10(1):34–43.

Robbins, R. L., D. E. Redfearn, and C. P. Stone. 1982. Refuges and elk management. Pages 479–507 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Skinner, C. K. 1922. The pronghorn. Journal of Mammalogy 3:82–105.

Smith, B. L., and R. L. Robbins. 1994. Migrations and management of the Jackson Elk Herd. National Biological Survey, Resource Publication 199.

Telfer, E. S., and J. P. Kelsall. 1984. Adaptation of some large North American mammals for survival in snow. Ecology 65:1828–1834.

Thorne, E. T., M. Meagher, and R. Hillman. 1991. Brucellosis in free-ranging bison: three perspectives. Pages 275–287 *in* R. B. Keiter and M. S. Boyce, editors. The greater Yellowstone ecosystem: redefining America’s wilderness heritage. Yale University Press, New Haven, Connecticut, USA.

Vogel, W. O. 1989. Response of deer to density and distribution of housing in Montana. Wildlife Society Bulletin 17:406–413.

Wilcove, D. S., C. H. McLellan, and A. P. Dobson. 1986. Habitat fragmentation in the temperate zone. Pages 237–256 *in* M. E. Soule, editor. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts, USA.

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ENERGETIC COSTS OF WILDLIFE DISPLACEMENT BY WINTER RECREATIONISTS

Herbivores (plant-feeding animals) often function at an energy deficit during the winter months. Snow impairs their access to food, increases the energy cost of gathering the food, and increases the cost of locomotion. Because plant growth has stopped, except in thermal areas, the food value of plants is often low unless the animal has access to points of energy storage such as buds. Snow characteristics and depth are controlling influences upon the winter distribution of plant-feeding animals. In the northern Rocky Mountains, limited winter access to food has led to the selection of species that have an enhanced ability to store energy. This energy store provides a large proportion of the energy necessary to carry on animal functions through the winter. The rest of the energy must be gathered from winter range areas. A consequence of the limited energy stores and limited food availability is that disturbance of animals by winter recreationists may result in increased energy expenditure with adverse effects upon the survival of the animal, its ability to give birth to and raise viable offspring, and the maintenance of the social dynamics of the population. At the same time, winter recreation produces packed snow travel routes that may enhance energy conservation by the animals. Such trails include the single-file trails produced by the flight of animals disturbed by recreationists, cross-country ski and snowshoe trails, and groomed road and trail systems provided for snowmobile use.

To provide guidelines for the management of winter recreationists so that undue depletion of the energy supplies of Yellowstone herbivores can be avoided, it is necessary to analyze animal response to humans at the individual level and the group level. Factors that affect and induce variability in the responses of animals are discussed along with energetic implications.

MECHANISMS OF RESPONSE

SENSORY LINKS TO HUMAN INTRUSION

The response of animals to intruders begins with the sensory envelope of the animal. The major senses involved in this response are those of sight, olfaction, and hearing. Each of these senses has its own threshold, character, and pattern of response that may vary between the different species as well as between the different populations of each species. One of the concepts that is of use in understanding these responses is the Weber-Fechner law of psychosensory perception. This rule demonstrates that a sensory stimulus must change by a fixed proportion in order for an animal to recognize that the stimulus has changed. This is called the “just noticeable difference” (JND) or Weber-Fechner constant (Withers 1992, Randall et al. 1997). Some responses to these sensory stimuli, such as moving or changes in posture, have energetic implications. Other responses, such as changes in heart rate, may or may not have energetic implications. Bighorn sheep and elk respond to humans that approach to within 55 yards by increases in heart rate (MacArthur et al. 1979, Cassirer and Ables 1990). Because cardiac output is a function of the stroke volume of the ventricles as well as the heart rate, an increase in heart rate does not necessarily mean an increase in cardiac output nor does it always mean an increase in energy consumption (Ganong 1997).

Vision is a major sense for most animals, although it may be less important in relative terms to them than it is to humans. The JND for vision is typically about 0.14, meaning that stimuli must change by 14 percent in order for the change to be detected. The range at which wild, large mammals typically show some sort of avoidance or suppression of activities is typically about ½ to 1 mile in open, relatively flat terrain (Ward et al. 1973, Lyon et al. 1985, Cassirer and Ables 1990). This zone of visual interference of use is reduced at night and under conditions of vegetative cover density and height that block vision. An energetic implication of this is that use of the winter range in this zone of relative exclusion is reduced to about half its normal level (Lyon et al. 1985). Bighorn sheep, in some circumstances, tolerate closer intrusion, which is probably related to both the limited nature and greater security furnished by their rough and broken habitat. The habituation state of the animals also affects their response and will be discussed later. While partial color vision has been demonstrated in some non-primate mammals, it has not been conclusively demonstrated in most mammal species. (Experiments on color vision, properly controlling luminance, saturation, and brightness at all visible light wavelengths, are difficult to do and have not been accomplished for most park mammals.) Thus, color does not seem to be of importance in triggering energetically expensive behavior. It is believed that some species, such as bighorn sheep, have specializations for high acuity of vision, while other species excel at detecting movement. Breaking the visual stimulus by crossing a ridgeline or other visual barrier is an important factor in responses to disturbance (Dorrance et al. 1973, Lyons et al. 1985, Cassirer and Ables 1990) and, thus, can be a significant factor in regulating energy expenditure.

Smell or olfaction is an important sensory element for mammals. Odors can be carried some distance by air currents and may be absorbed on snow and vegetation. Olfactory sensing of chemical odors has a high JND (about 0.3) indicating that only fairly substantial changes in odor can be noted. The deposition of olfactants on snow and plants has the potential for extending sensory responses for considerable periods of time. Accommodation to odors occurs rapidly, and mammals do not appear to show avoidance of snowmobile pollution in the snow (Aune 1981). Thus, the persistence of snowmobile pollution does not seem to be an important factor affecting energetics. Accommodation to one odor does not necessarily mean suppression of the ability to detect others. Thus, the olfactants deposited by snowmobiles (Aune 1981) are unlikely to interfere with the detection of predators by odor. Sensitivity to individual odors varies widely and differs between species. While olfaction is an important communication pathway, it appears to be unimportant in triggering highly energetic behavior after the rut is over but, like hearing, may reinforce visual response (Cassirer and Ables 1990).

Hearing has a JND of about 0.15. While several studies (Dorrance et al. 1973; Ward 1977; MacArthur et al. 1979, 1982; Stockwell et al. 1991) have focused upon the effect of relatively loud noises on animal behavior, it is often the relationship of a sound to the background noise level that is significant. Vegetation is highly effective in absorbing sound (Aylor 1971a and b; Harrison 1978). The sound level from an idling pickup truck was measured at 50 db about 90 yards from the vehicle in an open environment and at 70 yards in a mature forest in the Yellowstone area (Anderson 1994). Sound levels of 45 to 65 db at the point of animal toleration have been reported for snowmobiles in some studies

(Bury 1978). Better muffling and design have reduced snowmobile noise levels since these studies were done. The berms of snow along groomed snowmobile trails also tend to absorb and deflect sound.

The channeling of sound by inversions and dense air layers is common in mountain environments. A sound that is not heard near its source may occasionally be carried and perceived ½ mile or more distant without having been heard at intermediate distances. Air currents are also important in conveying sound. Cassirer and Ables (1990) observed that wind blowing toward animals increases movement away, suggesting that smell and hearing tend to accentuate the response triggered by vision. Animals may be expected to show some response at sudden or erratic sounds of 1 to 3 db in the quiet 30 db environment of a forest while requiring higher sound energies to produce a response if they are in a 60 db environment along a busy road. Constant noise levels are readily accommodated for and, as mammal populations on jet airports and airbases (Weisenberger et al. 1996) demonstrate, even predictable loud sounds can be ignored by animals. However, unpredictable noise can affect range utilization and movements of elk (Picton et al. 1985).

INDIVIDUAL RESPONSE

The energetic response of individual animals to human intrusion varies widely. One question that arises in Yellowstone is: where on the wild to domesticated continuum do various subpopulations fall as habituation is a physiological process with energetic consequences. Are the elk within the limits of the Mammoth development wild or domesticated? If they are domesticated, no energetic cost of human presence is involved. The chronically elevated resting heart rates of these animals (Cassirer and Ables 1990) indicate that this subpopulation is habituated rather than domesticated. Habituation reduces the physiological cost of dealing with an environmental stressor, but it seldom eliminates the cost entirely. This habituation has involved learning to ignore the large auditory and olfactory stimulation imposed by human activities while learning to rely almost entirely upon sight. Visual responses have been modified to permit human intrusion as close as 16–22 yards without eliciting flight behavior.

In the absence of other data, we can use weight and heart rate comparisons between the Lamar and the Mammoth elk to make a minimum rough estimate of the energetic differences between the two areas (Cassirer and Ables 1990). It appears that the direct energy cost for habituation and its prolonged alert status that is required for daily living in Mammoth is about 2 percent more than the cost of living in the Lamar. However, the more accessible and better forage provided by the green lawns of Mammoth results in a net daily energy intake in the range of 6–7 percent more than that in the Lamar. This gives the Mammoth elk a net advantage of about 4.5 percent. Year-to-year variations in winter severity probably have more effect on the Lamar animals than on the Mammoth elk. If calf production differences are included, the net energetic advantage of the Mammoth elk might be as much as 8 percent per day during the fall and winter months. Because this is based upon fall calf/cow ratios, the effects of a higher predation rate upon the calves in the Lamar is not considered. This failure to consider differences in predation would tend to overestimate the energy difference between the two areas. It should be noted that biological variation suggests that not all individuals in a population habituate equally as well to humans, thus, we would expect a population to contain a segment that habituates easily and another segment that shows more extreme avoidance behavior.

The travel routes of humans, such as roads and heavily used trails, are usually avoided to some extent by animals. A rough estimate suggests that perhaps 10 percent of the northern Yellowstone winter range has had its large herbivore-use capacity reduced by 50 percent (Lyon et al. 1985) due to use of the northeast entrance road between Mammoth and Cooke City. This road is a permanent feature of the environment, but the effects of it can be seen in plots of animal distribution along the route. This implies a lost-opportunity cost of perhaps 5 percent of the total energy supply of the range. It is unlikely that this "highway" effect has reduced the capacity of the Gibbon–Firehole range to the same degree. The nature of the geothermal range, its topography, high habituation levels of animals, and the lower energy statuses of the animals tend to reduce some of these impacts.

The energetic effects of disturbance are affected by seasonal changes in the energy balance of the animals, snow conditions, and distribution as well as annual variation in the conditions. The usual pattern of energy regulation in animals is to expend the energy consumed in the last meal rather than to consume energy to replace the energy that has been expended since the last meal (Hainsworth 1981). Thus, as energy stores drop, the tendency to conserve energy increases (Moen 1976), which will lead to a decrease in flight initiation distances upon being disturbed. This is the general pattern seen in flight initiation distances during the course of a winter. Research should be conducted to determine if disturbance of the animals results in increases in the length or frequency of feeding bouts, which would suggest some replenishment of energy stores. If food intake does not increase, a more critical effect upon the animals is implied.

Early in the winter, snow conditions tend to be better under the forest canopy than out in the open. The cold winters of Yellowstone encourage the ablation of snow from the forest canopy to a unique degree (Skidmore et al. 1994). This process can prolong the use of forest cover by the ungulates, which reduces the intensity of auditory as well as visual disturbance and its energetic consequences. The group size of elk tends to be smaller in the timber and their flight distances shorter, which results in less disturbance impact.

It is clear that the energetic expenditures of animals must be considered on the basis of their habituation status and energetic status as well as on snow depth. Calculations were performed for each of three different range situations: the Mammoth habituated population, the Lamar population, and the Gibbon–Firehole population. Estimations were calculated for a 590 lb. adult elk, a 200 lb. calf elk, a 150 lb. adult mule deer, and a 1,200 lb. bison under both early winter snow conditions and the dense snow conditions of late winter. The daily activity budget of elk was used as the activity budget for all of the ungulates (Nelson and Leege 1982). A density of 0.2 was assumed for the early winter powder-snow conditions, and a density of 0.4 for late winter compacted snow. Comparative calculations were done for no snow and for snow depths of 30 percent and 58 percent of brisket height. These depths were selected on the basis of the knee (carpel) length (Telfer and Kelsall 1984). Energy expenditures go up at exponential rates when snow depths are above the knee, conditions that are generally not tolerated by the animals. Parameters concerning energy expenditure were obtained from Parker et al. (1984) and Wickstrom et al. (1984). Behavioral responses to disturbances were obtained from Aune (1981), Cassirer and Ables (1990), and Freddy et al. (1986). The energetic expenditure due to changes in the "alert" behavioral status of the elk was estimated using Cassirer and Able (1990). The percentages expressed are for a total estimated daily energy budget of 7,072 kcal. for a 590 lb. adult elk; 2,861 kcal. for a 200 lb. calf elk; 2,243 kcal. for a 150 lb. adult mule deer; and, 11,167 kcal. for a 1,200 lb. bison. The cost of a single flight for a habituated adult elk increased the 7,072 kcal. daily energy budget between 3.2 and 7.1 percent, depending upon snow conditions, for an escape distance of 0.3 mile. The longer escape distance of 1.2 miles reported for the Lamar area (Cassirer and Ables 1990) gave energetic increases of 8.7 to 24 percent on level terrain. If the elk in the Lamar runs uphill for 60 percent and downhill for 20 percent of the time over a typical escape course (Cassirer and Ables 1990), energy costs may increase by 40 percent over the cost estimated for level terrain. High single-escape costs of more than 10 percent probably could not be tolerated by the elk throughout the entire winter season. Behavioral adjustment would probably be made to use slopes with less snow, shorter escape distances, or habituation. What might be perceived as a greater tolerance of the animals to disturbance as the winter season progresses might, in reality, be the result of these energy conservation responses as well as the influence of the lower energy status seen in late winter. The much shorter escape distances reported for the Firehole area may be reflective of the much more marginal energy status of these elk (Pils 1998) as well as habituation. The overall energy expenditure of the 200 lb. calf elk for the various situations averaged about 16.3 percent more than that of adults. The shorter legs of the calves dramatically increase escape costs in deep snow. The number of disturbances or close encounters necessary to produce habituation is unknown, but probably exceeds two per day. Habituation to cars or snowmobiles following highly predictable paths readily occurs. Habituation to the less predictable occurrence and movements of cross-country skiers and individuals on foot is a more difficult situation (Bury 1978, Schultz and Bailey 1978, Aune 1981, Ferguson and Keith 1982, Freddy et al. 1986).

For a habituated mule deer, the daily energetic expenditure of a single intrusive event is estimated to increase the daily energy budget of 2,861 kcal. by 2.5 to 5.9 percent. In the Lamar, responses increased energy expenditures 4.7 to 17 percent as compared to a range of increase of 1.8 to 2.2 percent for the Gibbon–Firehole area. The responses of mule deer were based upon the observations of Aune (1981) and Freddy et al. (1986).

Little information is available concerning the energetics of bison. Specific information concerning bison was obtained from Telfer and Kelsall (1984) and combined with general information covering large mammals in general (Parker et al. 1984, Wickstrom et al. 1984, Withers 1992). Personal observations suggest that bison are relatively unresponsive to human intrusion. Thus, the elk response data from the Gibbon–Firehole was used in the calculations. A single disturbance produces an increase in daily energy expenditure of 1.5 to 2.1 percent more than the 11,167 kcal. daily energy budget. The low, late-winter energy levels of bison may increase their tendency to allow close approach by humans and increase visitor hazards.

Failure to produce viable offspring has been suggested as a logical outcome of imposing high-energy disturbance stress upon animals. In an experimental situation, Yarmaloy et al. (1988) reported that it required direct targeting of a specific mule deer with a harassing all-terrain vehicle (ATV) repeated 15 times (averaging nine minutes each time) during October to induce reproductive disturbance. Deer not specifically targeted habituated to the ATVs with little apparent notice and suffered no reproductive consequences. No information is available to indicate the frequency of disturbance throughout the winter by recreationists or predators of individuals or individual groups of animals.

GROUP RESPONSE

"Single filing" is a major group response that affects the energetics of response to winter recreationists and the situations created by them. Single filing reduces the energy costs of travel through snow to a major degree. While the parameters of this type of movement have not been defined in the literature, unpublished field observations suggest that by the time the tenth animal passes along a trail, the energetic costs will be reduced to near the base level for locomotory activity. While short-distance flight movements are often individual, group movements will usually coalesce into single files for the longer travel distances, such as is seen in the Lamar area.

Of course, the single-file animal trails are not the only packed trails in the park. Wildlife will sometimes use foot trails as well as the groomed snowmobile trails to facilitate their movements. While cross-country ski trails or snowshoe trails are usually not attractive to the large mammals (Ferguson and Keith 1982), groomed or heavily used ski trails may be attractive to them.

The monthly average snow depths on the various portions of the Firehole–Madison winter ranges were from 6.5 to 10 inches in the severe winter of 1996–97 (Dawes 1998). In estimating energy consumption, let us assume travel through 18 inches of dense snow, which is about the maximum tolerated depth based upon the brisket height of an adult elk and is a slightly more extreme depth for the shorter legs of calf elk and bison. If we further assume that the usual daily activity budget of an ungulate involves 0.6 mile of travel, we can calculate that an adult bison will save about 4.3 percent of a normal daily energy budget by using the groomed roads. At snow depths of 9.5 inches, more comparable to that seen on the winter range, the savings during the December through March deep-snow period would be about 1.2 percent of the daily energy budget or an accumulated 1.4 days for the normal 11,167 kcal. daily energy budget. If we postulate a 22-mile migratory movement from the Fountain Flat area to West Yellowstone through 18 inches of dense snow, the groomed trail savings will be the equivalent of 1.66 days of the normal energy budget for a 1,200 lb. bison.

An adult elk has a smaller body size and longer legs than a bison. The daily savings for an elk under deep, dense snow conditions is estimated at 3.4 percent of the daily energy budget and 1 percent for the more normal snow conditions of 9.5 inches. The savings under the 18-inch, dense snow conditions would be about 1.2 days worth of energy, assuming the conditions persisted for the 121-day December through March period or 47 percent of the cost of maintaining a pregnancy from conception to the end of March. A 22-mile migration over a groomed trail would produce energy savings of about 1.1 days for the 7,072 kcal. daily energy budget equivalent under the deep, dense snow conditions. The energy savings experienced by the shorter limbed 200 lb. calf elk are estimated at 4.9 percent of the 2,861 kcal. daily energy budget for the 18-inch, dense snow conditions and 1.5 percent for the 9.5 inch snow levels. This is equivalent to a gain of about 1.8 days supply of energy for the 121-day winter period.

PREDATORS

The interaction, if any, between winter recreational disturbance of ungulates and predation is unknown. A range of effects, from enhancing predation effort by increasing energy depletion and sensory confusion in the ungulates to the use of humans as protective cover by ungulates, can be hypothesized. The medium to large predators in Yellowstone have lower foot loadings than the ungulates and, thus, can move over the snow much of the time. This serves to compensate for their shorter brisket heights. Although usually regarded as wilderness animals, wolverines will include clear-cut areas in their home ranges, and it has been speculated that later winter snowmobile use might affect habitat use (Hornocker and Hash 1981). Unpublished observations indicate that wolverines will use areas of terrain subjected to moderate uncontrolled snowmobile use (J. W. Williams, Montana Fish, Wildlife and Parks, personal communication). Wolves, foxes, coyotes, wolverines, and lynx are known to use roads and snowmobile and other trails when traveling (Neumann and Merriam 1972, International Wolf 1992, Ruggiero et al. 1994). The frequency of ungulate disturbance by either predators or humans is unknown. Avoidance of areas of intense human use by predators has also been reported.

MANAGEMENT GUIDELINES

- Make human use of wintering areas as predictable as possible. This can be done by restricting access and the timing of the access. Preferably, skiing should be restricted to mid-day hours and designated paths.
- Humans on foot should not approach wildlife, even those that are habituated, any closer than 20 yards; preferably, not closer than 55 yards.
- Escape breaks in the snow berms along plowed roads and groomed trails should be made to permit animals to easily leave the roadway. Crossing a deep snow berm often causes a brief but intense expenditure of energy. Animals in late winter condition may have considerable difficulty in producing the brief intense energy flow necessary to meet these demands.
- Any winter-use trails in close proximity (less than 700 yards) to major wildlife wintering areas should be screened by routing to put the trail behind ridgelines and vegetative cover.
- Low speed limits should be set on roads and snowmobile trails, particularly in winter range areas.
- Information, past and future, concerning snow depths, snowmobile use, and the reproductive ratios of each species and each major population segment should be collected and analyzed for indications of negative effects on wildlife.
- Information on the daily activity budgets and daily movement budgets of bison are lacking. This information could give considerable insight into the impacts of winter recreation upon this species and should be collected.
- Public information efforts concerning the winter ecology of animals should be conducted. Information concerning the actual frequency of disturbance is desirable for more definitive estimates of the energetic impacts resulting from winter recreationists. Information concerning the interaction of this disturbance with that produced by wolves is desirable.

LITERATURE CITED

Anderson, N. J. 1994. Grizzly bear food production on clearcuts within the western and northwestern Yellowstone ecosystem. Thesis, Montana State University, Bozeman, Montana, USA.

Aune, K. E. 1981. Impacts of winter recreationists on wildlife in a portion of Yellowstone National Park, Wyoming. Thesis, Montana State University, Bozeman, Montana, USA.

Aylor, D. 1971a. Noise reduction by vegetation and ground. Journal of the Acoustical Society of America 51-1:197–205.

———. 1971b. Sound transmission in relation to leaf area, density, leaf width, and breadth of canopy. Journal of the Acoustical Society of America 51-1:411–414.

Bury, R. L. 1978. Impacts of snowmobiles on wildlife. Transactions of the North American Wildlife Conference 43:149–156.

Cassirer, E. F., and E. D. Ables. 1990. Effects of disturbance by cross-country skiers on elk in northern Yellowstone National Park. Final Report to the National Park Service, Yellowstone National Park, Wyoming, USA.

Dawes, S. R. 1998. Utilization of forage by bison in the Gibbon, Madison, and Firehole areas of Yellowstone National Park. Thesis, Montana State University, Bozeman, Montana, USA.

Dorrance, M. J., P. J. Savage, and D. E. Huff. 1973. Effects of snowmobiles on white-tailed deer. Journal of Wildlife Management 39:563–569.

Ferguson, M. A. D., and L. B. Keith. 1982. Influence of Nordic skiing on distribution of moose and elk in Elk Island National Park, Alberta. Canadian Field Naturalist 96:69–78.

Freddy, D. J., W. M. Bronaugh, and M. C. Fowler. 1986. Responses of mule deer to disturbances by persons afoot and on snowmobiles. Wildlife Society Bulletin 14:63–68.

Ganong, W. F. 1997. Review of Medical Physiology, Eighteenth edition. Appleton and Lang, Stamford, Connecticut, USA.

Hainsworth, F. R. 1981. Animal physiology: adaptations in functions. Addison–Wesley, Reading, Massachusetts, USA.

Harrison, R. T. 1978. Quantifying the acoustic dose when determining the effects of noise on wildlife. Pages 267–285 *in* J. L. Fletcher and R. G. Busnel, editors. Effects of Noise on Wildlife, Academic Press, New York, New York, USA.

Hornocker, M. G., and H. S. Hash. 1981. Ecology of the wolverine in northwestern Montana. Canadian Journal of Zoology 59:1286–1301.

International Wolf. 1992. Snowmobiles versus wolves (comments from a survey of 40 wolf biologists). March 1992.

Lyon, L J., T. N. Lonner, J. P.Weigand, C. L. Marcum, W. D. Edge, J. D. Jones, D. W. McCleerey, and L. L. Hicks. 1985. Coordinating elk and timber management. Final report of the Montana cooperative elk-logging study 1970–1985. Montana Fish, Wildlife and Parks Department, Helena, Montana, USA.

MacArthur, R. A., R. H. Johnson, and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. Canadian Journal of Zoology 57:2010–2021.

MacArthur, R. A., V. Geist, and R. H. Johnson. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. Journal of Wildlife Management 46:351–358.

Moen, A. N. 1976. Energy conservation by white-tailed deer in the winter. Ecology 57:192–198.

Nelson, J. R., and T. A. Leege. 1982. Nutritional requirements and food habits. Pages 323–367 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America. Stackpole Books, Harrisburg, Pennsylvania, USA.

Neumann, P. W., and H. G. Merriam. 1972. Ecological effects of snowmobiles. Canadian Field Naturalist 86:207–212.

Parker, K. L., C. T. Robbins, and T. A. Hanley. 1984. Energy expenditures for locomotion by mule deer and elk. Journal of Wildlife Management 48:474–488.

Picton, H. D., J. E. Canfield, and G. P. Nelson. 1985. The impact of a 500 KV transmission line upon the north Boulder winter elk range. Final Report. U.S. Forest Service contract 53-0398-30E-3.

Pils, A. 1998. Sampling and analysis methods for snow urine nutritional assays. Thesis, Montana State University, Bozeman, Montana, USA.

Randall, D., W. Burggren, and K. French. 1997. Animal physiology: mechanisms and adaptations. W. H. Freeman, New York, New York, USA.

Ruggiero, L. F., K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski. 1994. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the western United States. General Technical Report RM-254. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Schultz, R. D., and J. A. Bailey. 1978. Responses of national park elk to human activity. Journal of Wildlife Management 42:91–100.

Skidmore, P., K. Hansen, and W. Quimby. 1994. Snow accumulation and ablation under fire-altered lodgepole pine canopies. Pages 43–52 *in* C. Troendle and J. K. Marron, editors. Proceedings of the 62nd Annual Western Snow Conference. Santa Fe, New Mexico, USA.

Stockwell, C. A., G. C. Bateman, and J. Berger. 1991. Conflicts in national parks: a case study of helicopters and bighorn sheep time budgets at the Grand Canyon. Biological Conservation 56:317–328.

Telfer, E. S., and J. P. Kelsall. 1984. Adaptation of some large North American mammals for survival in snow. Ecology 65:1828–1834.

Ward, A. L. 1977. Telemetered heart rate of three elk as affected by activity and human disturbances. Proceedings of a Symposium on Dispersed Recreation and Natural Resource Management. Utah State University, Logan, Utah, USA.

———, J. J. Cupal, A. L. Lea, C. A. Oakley, and R. W. Weeks. 1973. Elk behavior in relation to cattle grazing, forest recreation, and traffic. Proceedings of the North American Wildlife Conference 38:327–337.

Weisenberger, M. E., P. R. Krausman, M. C. Wallace, D. W. De Young, and O. E. Maughan. 1996. Effects of simulated jet aircraft noise on heart rate and behavior of desert ungulates. Journal of Wildlife Management 60:52–61.

Wickstrom, M. L., C. T. Robbins, T. A. Hanley, D. E. Spalinger, and S. M. Parish. 1984. Food intake and foraging energetics of elk and mule deer. Journal of Wildlife Management 48:1285–1391.

Withers, P. C. 1992. Comparative animal physiology. Saunders College, New York, New York, USA.

Yarmaloy, C., M. Bayer, and V. Geist. 1988. Behavior responses and reproduction of mule deer following experimental harassment with an all-terrain vehicle. Canadian Field Naturalist 102(3):425–429.

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Impacts of Two-Stroke Engines on Aquatic Resources

Human recreational activities impact aquatic resources directly and indirectly. Winter recreation affects aquatic organisms mainly by indirect impacts due to pollution. Two-stroke engines can deposit contaminants on snow, leading to ground and surface water quality degradation, which subsequently may impact aquatic life.

Life History and Status

Fish are important components of aquatic ecosystems and are important links in the transfer of energy between aquatic and terrestrial environments. Native and non-native fish, aquatic microorganisms, insects, and crustaceans integrate into a complex aquatic community. In Yellowstone National Park there are 12 native and 6 introduced fish species (Varley and Schullery 1983). In the Yellowstone area and the Rocky Mountain region, trout and other salmonids (Family Salmonidae) are the major game species. Native fish include Yellowstone cutthroat trout (*Oncorynchus clarki bouvieri*), westslope cutthroat trout (*O. clarki lewisi*), Snake River cutthroat trout (*O. clarki*), arctic grayling (*Thymallus articusi*), mountain whitefish (*Prosopium williamsoni*), mountain sucker (*Catostomus platyrhnchus*), longnose sucker (*C. catostomus griseus*), Utah sucker (*C. ardens*), mottled sculpin (*Cottus bairdi*), redside shiner (*Richardsonius hydrophlox*), Utah chub (*Gila atraria*), longnose dace (*Rhinicthys cataractae*), and speckled dace (*R. osculus*). Non-native fish species include rainbow trout (*O. mykiss*), brown trout (*Salmo trutta*), eastern brook trout (*Salvelinus fontinalis*), lake trout (*S. namaycush*), and lake chub (*Couesius plumbeus*).

Some fish species are becoming endangered as populations decrease from human exploitation, environmental degradation, and competition and predation from exotic or introduced species. While no fish species in the Yellowstone area are listed under the Endangered Species Act, the fluvial Arctic grayling, westslope cutthroat trout, and Yellowstone cutthroat trout are considered species of concern in Wyoming, Montana, and Idaho. All three species have been petitioned for federal listing under the Endangered Species Act (50 CFR Part 17), and it has been determined that listing of the fluvial Arctic grayling as endangered is warranted but precluded at this time. Determinations for the other two species are pending.

Human Activities

Much of the existing literature relating to impacts on aquatic biota has been restricted to outboard engines on boats that discharge a variety of hydrocarbon compounds directly into the water column (Bannan 1997). However, the discharge of snow machine exhaust directly into accumulated snow may provide a corollary. For example, emissions from snowmobiles have been implicated in elevated lead contamination of snow along roadsides (Ferrin and Coltharp 1974). Although lead is no longer a concern, hydrocarbons are still deposited on the top layer of snow along snowmobile trails (Adams 1974).

Contaminants from two-cycle engine exhaust include carbon monoxide, hydrocarbons, Methyl-*tert*-butyl ether (MTBE), Nitrous oxides (NO_x), and particulate matter (White and Carrol 1998). Considerable variation exists among these compounds with respect to toxicity and persistence in water or aquatic sediments. Temperature and dilution rate (*i.e.*, mixing by propellers) appear to affect volatility (*e.g.*, evaporation rate) and long-term distribution of specific compounds. Because two-cycle engine exhaust contains numerous types of hydrocarbons, analyses typically focus on effects of only the more persistent types, particularly polycyclic aromatic hydrocarbons (PAH).

Studies of Lake Tahoe suggest that localized reductions of zooplankton populations may occur in areas of high boat usage. Deleterious effects can occur both in terms of mortality and histopathological response (Tahoe Research Group 1997). Extensive laboratory tests in Sweden documented that rainbow trout exposed to typical levels of engine exhaust could be negatively affected in growth rates, enzyme function, and immune responses (Balk et al. 1994). Also, sex-specific differences were observed, which could lead to alteration of normal reproductive function. MTBE is an oxygenated additive emitted from engine exhaust that is soluble in water and does not break down readily. However, no formal Environmental Protection Agency (EPA) drinking water standards are set for this compound. Nitrous oxides contain nitrogen, which can be a limiting nutrient in aquatic systems. It is considered a small risk because of its small percentage to total atmospheric deposition rates. However, it can contribute to eutrophication. As a result, some concerned investigators have recommended restrictions on the number of two-cycle engines allowed in high usage areas of Lake Tahoe (Tahoe Research Group 1997). Similar concerns have been voiced for Lake Michigan, Isle Royale National Park, and San Francisco Bay.

Under certain environmental conditions, toxicity of some PAH compounds may increase substantially. The toxicity of PAH can be "photo enhanced" in the presence of ultraviolet light (UV) and become 50,000 times more toxic under field conditions in the presence of sunlight. When PAH are in the bodies of aquatic organisms and absorb UV light, the energized molecules or their reactive intermediates can react with biomolecules to cause toxicity that can lead to death of aquatic organisms (Allred and Giesy 1985, Holst and Giesy 1989).

Impacts to aquatic species that can be attributed to atmospheric deposition from snowmobiles have not been well studied. Field studies are extremely difficult to conduct because atmospheric deposition rates could be affected by numerous factors, including temperature, proximity to water, and combustion efficiency of individual snowmobiles. One of the more extensive studies used caged brook trout to determine effects of exhaust on fish. Exhaust components taken up by fish correlated with levels present in the environment as a result of snowmobile use (Adams 1974). Uptake of exhaust hydrocarbons and other compounds occur through the gills during respiration. It is thought that hydrocarbons are incorporated into fatty tissues, such as visceral fat and the lateral line, in a manner similar to chlorinated hydrocarbon pesticides.

Tremendous uncertainty accompanies discussion of this topic with reference to affects on aquatic resources of the GYA. The current lack of quantitative data reduces comparisons between outboard engines and anticipated effects from a specific level of snowmobile use. However, it appears reasonable that higher concentrations from emissions will likely accumulate as a result of grooming roads with the constant packing of exposed snow. These accumulated pollutants will enter adjacent watersheds during the spring melt, which generally occurs from April through June. Pollutants entering the watershed will be concentrated during this snowmelt, producing a strong "pulse" in the system. Similarly, impacts from acid rain in the eastern United States are confounded by the accumulation of the acid in snow, with subsequent melting producing a pulse of acidity in a short time and causing very low pH in many streams (Carline et al. 1992, Haines 1981).

Potential Effects

Protection of park aquatic resources and restoration of native species are primary management goals of the National Park Service. In Yellowstone National Park, groomed snowmobile roads are often adjacent to major aquatic systems (*e.g.*, Firehole River, Madison River, Gibbon River, Yellowstone River, Lewis River, and Yellowstone Lake). The Yellowstone River from the Yellowstone Lake outlet to the Upper Falls contains Yellowstone cutthroat trout. The Madison River is a potential reintroduction site for westslope cutthroat trout. The Gibbon and Madison rivers may contain fluvial Arctic grayling. Snowmobiling occurs on Hebgen, Jackson, and other small lakes located in the greater Yellowstone area. There are also areas where snowmobiles cross open water.

Hydrocarbon pollution in water may initially persist on the surface but will eventually settle into the water column, increasing exposure to fish and invertebrates. Investigations have shown dramatic increases in some contaminants in water exposed to snowmobile exhaust; some of these increases are on the order of 30 times (Adams 1974). Accumulation may also occur in sediments (Lazrus et al. 1970). Fish receive contamination from different trophic levels that are sustained in both open water and sediment environments. These pollutants accumulate in the food chain, and accumulations in fish would result in uptake by piscivorous predators including bald eagle, osprey, otter, pelican, and grizzly bear.

Physiological responses of fish to increased loads of hydrocarbons and other contaminants may increase direct and indirect mortality rates. Rainbow trout and cutthroat trout begin spawning in early spring (March through July), exposing developing embryos during this period. Research has shown that even at extremely low levels of hydrocarbon pollution, impacts may include chromosomal damage; retarded growth and development; disruption of normal biological functions, including reduced stamina for swimming and maintaining positions in streams (Adams 1974); and death.

Invertebrate vulnerability is not known; however, it is likely that early instar development may be impacted by hydrocarbon pollution entering the water. Many winter shredders (invertebrates that consume large organic debris) are emerging, mating, and laying eggs in early spring (*e.g.*, stoneflies). These developing embryos may, therefore, be more susceptible to pollutants during spring runoff periods.

Impacts of winter recreational activities on fish and other aquatic resources occur mostly where oversnow machines concentrate along groomed motorized routes and winter destination areas. In situations where snowmobiling occurs over open water (D. Trochta 1999), obvious impacts will include direct discharge into aquatic habitats. Appreciable contamination from emissions from backcountry snowmobiling probably occurs less frequently. However, dispersed snowmobile travel affects vegetation (J. T. Stangl 1999), causing erosion and damaging natural water courses and banks. Snowmobiles can cause degradation of stream and lake quality and affect aquatic species and their habitat.

Management of oversnow machine recreation should encourage the development of clean emission standards. Strict emission requirements for two-stroke engines would mitigate impacts to water quality and, subsequently, aquatic environments. Restricting motorized winter recreation near streams, lakes, and wetland habitats would minimize direct impacts to aquatic resources.

LITERATURE CITED

Adams, S. E. 1974. Effects of lead and hydrocarbons from snowmobile exhaust on brook trout *Salvelinus fontinalis*. Transactions of the American Fisheries Society 104(2):363–373.

Allred, P. M., and J. P. Giesy. 1985. Solar radiation induced toxicity of anthracene to *Daphnia pulex*. Environmental Toxicology and Chemistry 4:219–226.

Balk, L., G. Ericson, E. Lindesjoo, I. Petterson, U. Tjarnlund, and G. Akerman. 1994. Effects of exhaust from two-stroke outboard engines on fish. Nordic Council of Ministers, Copenhagen, Denmark.

Bannan, M. 1997. The effects of powerboat emissions on the water quality of Loch Lomond. Post-graduate annual report. Glascow University and University Field Station, Great Britain.

Carline, R. F., W. E. Sharpe, and C. J. Gagen. 1992. Changes in fish communities and trout management in response to acidification of streams of Pennsylvania. Fisheries 17(1):33–38.

Ferrin, R. S., and G. P. Coltharp. 1974. Lead emissions from snowmobiles as a factor in contamination of snow. Proceeding of the Utah Academy of Science, Arts and Letters 51(1):116–118.

Haines, A. 1981. Acid precipitation and its consequences for aquatic ecosystems: a review. Transactions of the American Fisheries Society 110:669–707.

Holst, L. L., and J. P. Giesy. 1989. Chronic effects of the photo-enhanced toxicity of anthracene on *Daphnia magna* reproduction. Environmental Toxicology and Chemistry 8:933–942.

Lazrus, A. L., E. Lorange, and J. P. Lodge, Jr. 1970. Lead and other metal ions in United States precipitation. Environmental Science and Technology 4(1):55–58.

Tahoe Research Group. 1997. The use of two-cycle engine watercraft on Lake Tahoe: water quality and limnological considerations. Report to Tahoe Regional Planning Agency, Lake Tahoe, California, USA.

Stangl, J. T. 1999. Effects of recreation on vegetation. Pages 119–121 *in* T. Olliff, K. Legg, and B. Kaeding, editors. The effects of winter recreation on wildlife: a literature review and assessment. National Park Service, Yellowstone National Park, Wyoming, USA: In Press.

Trochta, D. 1999. The effects of snowmobiling across open water. Pages 161–162 *in* T. Olliff, K. Legg, and B. Kaeding, editors. The effects of winter recreation on wildlife: a literature review and assessment. National Park Service, Yellowstone National Park, Wyoming, USA: In Press.

Varley, J. D., and P. Schullery. 1983. Freshwater wilderness: Yellowstone fishes and their world. Yellowstone Library and Museum Association, Yellowstone National Park, Wyoming, USA.

White, J. W., and J. N. Carrol. 1998. Emissions from snowmobile engines using biobased fuels and lubricants. Report prepared for the state of Montana Department of Environmental Quality, Helena, Montana, USA.

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EFFECTS OF WINTER RECREATION ON HABITUATED WILDLIFE

Little information exists on the direct and indirect impacts of winter recreation on most wildlife species. However, these effects may create potentially additive or synergistic impacts to wildlife populations (Knight and Cole 1995). Effects include energetic response to humans and human facilities, habituation to human activities, and attraction or conditioning to human foods and garbage (Herrero 1987).

Most wildlife species that become habituated or food conditioned from winter recreational activity are not protected under federal law. These include ungulate populations accustomed to winter recreationalists, roads, and snowmobile trails (Aune 1981, Meagher 1993), and carnivores, such as coyote, red fox, pine marten, that become food conditioned to human foods at recreational facilities. Bird species, including ravens, gray jays, and Clark's nutcrackers, also may become food conditioned and are protected under the Migratory Bird Treaty Act. Both black and grizzly bears have the potential to become habituated to human activities and food conditioned to human foods (Mattson 1990), but are typically not active during the winter season (Judd et al. 1986).

All wildlife species are protected in national parks (NPS 1988). On lands outside national parks, some wildlife species are subject to hunting. Most non-game bird species are protected from direct human-caused mortality by the Migratory Bird Treaty Act (U.S.C. Title 16, Section 703). Species in the Yellowstone area protected by the Endangered Species Act of 1973 (U.S.C. 1531, 1982 ammend.) include the whooping crane and peregrine falcon, which are endangered, and the bald eagle and grizzly bear, which are threatened. Whooping cranes and peregrine falcons are not considered winter residents of the Yellowstone area. Gray wolves were recently reintroduced to the Yellowstone area. While naturally occurring wolves are classified as endangered in Montana, Idaho, and Wyoming, those reintroduced into the Yellowstone and central Idaho ecosystems in 1995 and 1996 were reclassified as "experimental/non-essential populations" (USFWS 1994).

LIFE HISTORY

Many wildlife species are residents of the Yellowstone area during winter. Terrestrial species include bison, elk, mule deer, moose, bighorn sheep, mountain lion, lynx, bobcat, marten, fisher, river otter, wolverine, coyote, gray wolf, red fox, and snowshoe hare. Avian species include bald eagle, trumpeter swan, common raven, gray jay, Clark's nutcracker, great gray owl, waterfowl, raptors, and passerine bird species.

Many wildlife species migrate or become inactive during winter months. Others however, remain and adjust their foraging, habitat use, and activity patterns to winter conditions. While most winter animals are well adapted to surviving winter situations, winter environments typically create added stress to wildlife due to harsher climatic conditions and more limited foraging opportunities.

HUMAN ACTIVITIES

Winter recreation has the potential to affect wildlife foraging patterns, habitat use, and interaction with human activities. When winter recreation occurs, some wildlife species may become accustomed to people and, therefore, habituated to human activities. A further step in this process occurs when animals gain and then seek out human foods (Herrero 1985). Examples of the effect of wildlife habituation in winter recreational situations include:

1. Bison in Yellowstone National Park utilize groomed snowmobile roads as travel routes (Aune 1981, Meagher 1993).
2. Ravens converge at winter destination areas, such as developed areas and warming huts, and forage on human foods discarded or left unattended in snowmobile seat compartments and/or packs; this results in property damage.
3. Coyotes and red foxes frequent winter developments and warming huts to seek hand-outs from visitors or forage on improperly discarded food scraps. Some eventually display aggressive behavior, sometimes harming visitors. These animals are removed from the area or destroyed.
4. Areas of winter garbage storage inside and outside Yellowstone National Park attract an array of wildlife species including coyotes, red foxes, pine martens, red squirrels, ravens, magpies, and gray jays.

POTENTIAL EFFECTS

Very little information exists on specific effects of winter recreation on habituated wildlife. Moreover, the need for more specific scientific monitoring is essential to better understand the complexities of wildlife–human interactions and the direct and indirect effects that winter recreation create on wildlife populations. It is sometimes difficult to determine whether wildlife habituation can be an advantage or a detriment to populations. Studies have indicated a shorter flight distance and a higher tolerance for vehicles and humans as a result of habituation (Aune 1981, Gabrielson and Smith 1995). However, habituation can also lead to unnatural attraction to human-use areas and lead to direct management actions and subsequent human-caused mortality (Herrero 1985, Mattson 1990, Mattson et al. 1992).

Potential Opportunity Areas that will be particularly affected include:

(1) Destination areas. Highly developed destination areas may negatively impact wildlife where winter recreational sites occur in habitats that wildlife occupy. Winter destination areas are becoming more popular. These include major ski areas and park development areas, and park gateway communities. These can also be low or moderately used areas such as small residential communities and warming huts. Wildlife avoidance of habitats could occur near winter developments. However, the more obvious management concern arises when animals are attracted to developments in search of human foods.

In areas with strong bear management guidelines, such as Yellowstone National Park, a strong emphasis is placed on food storage and security (Gunther 1994). However, in winter when bears are hibernating, a lapse in food security appears more common. Managers associated with winter recreational developments should maintain high standards of food security to prevent wildlife species other than bears from becoming attracted to human facilities and foods. Garbage storage facilities should be secured from all forms of wildlife.

Planning for new winter recreational developments should include designs for animal-proof food- and garbage-storage facilities and avoid areas that could lead to animal attraction. Areas such as cooking and eating facilities, picnic areas, and garbage collection sites should be built to preclude wildlife attraction and habituation.

(2) Primary transportation routes and (3) scenic driving routes. Year-round roads may have significant effects on habituated wildlife. Primary roads may impact wildlife by creating situations where animals seek road habitats in search of food. This may occur because people feed wildlife along roadsides or, to a lesser extent, because animals scavenge dead animals killed along roads. Both types of foraging bring wildlife to roadsides and create further habituation and increase risk of mortality (Gunther et al. 1998). Wildlife managers should try to remove roadside carcasses to avoid scavengers being hit by vehicles.

(4) Groomed motorized routes. Snowmobile traffic along high- and moderate-groomed routes may pose a significant problem to habituated wildlife during the winter months. The potential for conflict could occur when animals seek groomed routes in search of food. This may occur from recreationists feeding wildlife along groomed roads or possibly with animals scavenging carcasses killed along these routes. Both types of feeding bring wildlife to groomed roadsides and create further habituation and increased risk of mortality. Wildlife managers should try to remove carcasses to prevent scavengers from being hit by over-snow vehicles.

Grooming of roads and snowmobile trails may affect ungulate movements, population dynamics, and management actions (Meagher 1993). Planning for new snow routes should avoid ungulate winter range and important wildlife habitat.

(6) Backcountry motorized areas. Ungroomed snowmobile areas may one day pose a significant habituated wildlife problem. Areas of ungroomed snowmobile use typically occur at low levels and should not attract wildlife. The potential for conflicts between wildlife and recreationists would occur when winter snowmobiling increases to higher densities and careless food security is common.

(9) Backcountry nonmotorized areas. Backcountry skiing, snowshoeing, and downhill sliding should not pose a problem to habituated wildlife. The potential for wildlife–human conflicts may occur when high-density, human winter recreational activity occurs and food security is a problem.

LITERATURE CITED

Aune, K. E. 1981. Impact of winter recreationists on wildlife in a portion of Yellowstone National Park, Wyoming. Thesis, Montana State University, Bozeman, Montana, USA.

Gabrielson, G. W., and E. N. Smith. 1995. Physiological responses of wildlife to disturbance. Pages 95–108 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistance through management and research. Island Press, Washington, D.C., USA.

Gunther, K. A. 1994. Bear management in Yellowstone National Park, 1960–93. International Conference on Bear Research and Management 9:549–560.

Gunther, K. A., M. J. Biel, and H. L. Robison. 1998. Factors influencing the frequency of roadkilled wildlife in Yellowstone National Park. Pages 32–42 *in* G. L. Evink, P. Garrett, D. Ziegler, and J. Berry, editors. Proceedings of the International Conference on Wildlife Ecology and Transportation. Florida Department of Transportation FL-ER-69558. Fort Meyers, Flordia, USA.

Herrerro, S. 1985. Bear attacks; their causes and avoidance. Winchester Press, Piscataway, New Jersey, USA.

Judd, S. L., R. Knight, and B. Blanchard. 1986. Denning of grizzly bears in the Yellowstone National Park area. International Conference on Bear Research and Management. 4:359–367.

Knight, R. L., and D. N. Cole. 1995. Wildlife response to recreationalists. Pages 71–80 *in* R. L. Knight and K. J. Gutzwiller editors. Wildlife and recreationists: coexistance through management and research. Island Press, Washington, D.C., USA.

Mattson, D. J. 1990. Human impacts on bear habitat use. International Conference Bear Research and Management 8:33–56.

———, B. M. Blanchard, and R. R. Knight. 1992. Yellowstone grizzly bear mortality, human habituation, and whitebark pine seed crops. Journal of Wildlife Management 56:432–442.

Meagher, M. M. 1993. Winter recreation induced changes in bison numbers and distribution in Yellowstone National Park. Unpublished report. Yellowstone National Park, Wyoming, USA.

NPS (National Park Service). 1988. National Park Service 88: management policies. National Park Service, Washington, D.C., USA.

USFWS (U.S. Fish and Wildlife Service). 1994. The reintroduction of gray wolves to Yellowstone National Park and central Idaho. Final Environmental Impact Statement. U.S. Fish and Wildlife Service, Helena, Montana, USA.

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EFFECTS OF HELISKIING ON WILDLIFE

Heliskiing is the use of helicopters to take skiers and snowboarders to the tops of mountain slopes that have generally been unused by other skiers or snowboarders. Typically, this activity occurs in the more remote backcountry mountains that are difficult to access by foot. Heliskiing is becoming popular in Colorado, Utah, Idaho, and Canada. Where there is snow and remote mountain slopes, there is the potential for heliskiing.

There is currently no permitted helicopter skiing use in the Greater Yellowstone Area (GYA), although a few requests have been made for permits on some forests. Some poaching (non-permitted use) does occur in the Bridger Range and may occur elsewhere.

Although helicopter skiing is not a current problem, managers need to look ahead and gather information on helicopter skiing to prevent conflicts between wildlife and heliskiers. Some managers on national forests where heliskiing now occurs state that if heliskiing is not now a permitted use in the GYA, then it should not be allowed.

Although some Potential Opportunity Areas in the GYA will not be directly accessed by skiers, the noise or sight of the helicopter will likely affect all the areas. Areas where the helicopter stages (*i.e.*, along roads, trailheads) could become a problem, and helicopters flying over wildlife winter range may affect the wintering wildlife. The Potential Opportunity Areas that will be most affected include:

(2) Primary transportation routes
(3) Scenic driving routes
(6) Backcountry motorized areas
(7) Groomed nonmotorized routes
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(10) Downhill sliding (nonmotorized)
(11) Areas of no winter recreational use
(12) Low-snow recreation areas

POTENTIAL PROBLEMS WITH HELICOPTER SKIING

Numerous studies have shown impacts to wildlife from low-flying aircraft, including helicopters. Studies have been conducted on birds, mountain goats, wild sheep, deer, elk, and wolverines (Knight and Cole 1995). Exposure to helicopters increases energy expenditures, reduces fat accumulation, and/or changes an animal's physiological condition (MacArthur et al. 1979). These effects may lead to reduced survivability and/or reproduction success.

Other risks associated with helicopter skiing are avalanches, mishaps with the explosives used to set avalanches, and the potential for helicopter accidents. Helicopter accidents could result in wreckage and fuel spills in pristine backcountry areas. Any of these risks could be harmful to wildlife in the wrong place at the wrong time. Impacts from recreation add to the many stresses an animal sustains during the winter and can result in changes in movements and preferred ranges, reduced foraging efficiency, decreased reproductive success, increased chance of accidents, lowered resistance to disease, and increased predation (USFS 1996).

The impacts of helicopters on individual wildlife species are described below.

BALD EAGLES AND GOLDEN EAGLES

Bald eagles exhibited various responses to aircraft depending upon encounter distance and aircraft type. Eagles responded more negatively to helicopters within 1.8 miles than to fixed-winged aircraft. If young eagles were present, the adult eagles would remain on the nest, but if no young were present, the eagles would leave the nest and sometimes attack the helicopter. Researchers found no direct evidence of adult or young eagle mortality associated with aircraft harassment (Watson 1993). Watson suggests that the use of turbine-engine helicopters may have less impact on eagles, since these helicopters are quieter than piston-driven helicopters. All aircraft should remain a minimum of 65 yards from nests and stay within the nest area for less than 10 seconds. If there is a known nesting site, heliskiing operations should not be permitted within the area of the nest.

In the Wasatch Mountains of Utah, managers have expressed concern about a helicopter skiing permit that overlaps golden eagle range. It is likely that golden eagles would exhibit responses to helicopters similar to those of bald eagles.

MOUNTAIN GOATS

Mountain goats are found in all the mountain ranges of the GYA, and heliskiing areas could overlap with important winter habitats, potentially having a negative impact on the goats. Mountain goats winter at higher elevations, often at elevations higher than 7,000 feet, on south-facing slopes with windblown ridges. They prefer to be within 1,300 feet of escape terrain. In the winter months, goats minimize their movements, foraging during the warm parts of the day, decreasing energy expenditures.

A study of the effects of helicopter disturbance from mining activities showed some adverse impacts to mountain goats (Côté 1996). Côté found an inverse relationship between the goat's response to the altitude of the helicopter above the animal. He believes that mountain goats are more sensitive than other open-terrain ungulates. Goats responded most negatively when the helicopter was within 540 yards. Animals did not habituate to repeat overflights and responded in the same manner whether it was the first flight of the day or subsequent flights. When a helicopter was present in an area for many hours, the goats remained alert during the entire period and did not forage. Helicopters at close range caused mountain goat groups to split apart, and in some cases animals became injured. Côté recommends that a 1¼-mile buffer be placed around mountain goat herds to decrease the harmful effects of helicopters on the goats.

Similar negative impacts to goats were discussed in the environmental assessment of helicopter skiing on the Ketchum Ranger District of Idaho (USFS 1996). The biological assessment found that mountain goats ran when the helicopter was within 1/3 mile. Joslin (1986) noted that mountain goat behavior was changed negatively in response to helicopters used for seismic exploration. A study on the Beartooth Plateau, Montana, recommended that snowmobiles not be permitted within one mile of goat habitat (Haynes 1992); a similar recommendation should be made for helicopters.

If helicopter skiing is ever permitted in the GYA, mountain goat winter and spring ranges should be avoided.

ELK

Elk wintering at high elevations or along the route that a helicopter travels may be negatively affected by the aircraft because of increased energy expenditures in response to the disturbance. In the environmental assessment of helicopter skiing in the Ketchum Ranger District (USFS 1996), elk were identified as a species of concern.

BIGHORN SHEEP

Helicopter skiing would affect bighorn sheep in the same manner that it would affect mountain goats and elk. Jorgensen (1988) documented that bighorns abandoned winter range during the 1988 Winter Olympics. Helicopter flights, avalanche blasting, and human activity on ridge tops pushed the resident sheep to less optimal habitats. Bighorns are also negatively affected in the Grand Canyon as a result of helicopter overflights (Stockwell and Bateman 1991).

WOLVERINES

Female and male wolverines range 238.5 square miles and 983 square miles, respectively. Females den from mid-February through April. Den habitat is in subalpine, north-facing cirques with large boulder talus. This type of habitat is similar to the type of area used by heliskiers. Wolverines are sensitive during the denning periods, and females have been known to move their kits if people or human tracks are near the den site. Wolverines and helicopter skiing were discussed in the environmental assessment of helicopter skiing in the Ketchum Ranger District (USFS 1996). Heliskiing should be avoided in areas where wolverines are known to occur, especially if the activity is near denning habitat.

OTHER WILDLIFE

Many other species of wildlife could be negatively affected by helicopter skiing. Wolves and other carnivores may be impacted if prey species, such as elk, alter their behavior because of helicopter presence. There could be a positive result for predators if their prey becomes more susceptible to predation. Peregrine falcons may be bothered in the springtime during the breeding period if helicopter skiing is occurring in their territory. It is unknown how heliskiing might affect the lynx.

THE EFFECTS OF NOISE ON WILDLIFE

Knight and Cole (1995) examined the effects of noise on wildlife and found that noise from helicopters could be damaging to animals. Wildlife exposed to loud noises show an elevated heart rate. Noise can harm the health of an animal by altering reproduction (loss of fertility, harm during early pregnancy), survivorship, habitat use and distribution, abundance, or by interrupting torpor or hibernation. Animals may develop an aversion or avoidance response and show high levels of antagonistic behavior and decreased levels of food intake in areas with chronically loud noise. Animals may show signs of either acute or chronic hearing loss that could lead to masking other life-threatening noises, such as the approach of a predator. Wildlife abandonment of preferred habitat and the repeated reaction to avoid inescapable noises may lead to an increase in energetic expenses.

MANAGEMENT GUIDELINES

Heliskiing use should be limited to the minimal amount of area possible, and overflight distances should be more than 1,000 feet above and 2 miles away from sighted wildlife or known wildlife winter habitat. Managers should overfly proposed heliskiing areas to determine locations of wildlife and prohibit skiing where conflicts would occur. The permittee should be required to notify managers of any wildlife sightings as well as the areas that were used. Managers should have the authority to close any area that is in question. There should be no overflights or use of slopes with known wolverine dens. The use of explosives to set off avalanches should be limited, and any wildlife or human presence should be ascertained before use.

LITERATURE CITED

Côté, S. D. 1996. Mountain goat responses to helicopter disturbance. Wildlife Society Bulletin 24:681–685.

Haynes, L. A. 1992. Mountain goat habitat of Wyoming's Beartooth Plateau: implications for management. Biennial Symposium of the North American Wild Sheep and Goat Council 8:325–339.

Jorgenson, J. T. 1988. Environmental impact of the 1988 winter Olympics on bighorn sheep of Mount Allan. Biennial Symposium of the North American Wild Sheep and Goat Council 6:121–134.

Joslin, G. 1986. Mountain goat population change in relation to energy exploration along Montana's Rocky Mountain front. Biennial Symposium of the North American Wild Sheep and Goat Council 6:253–271.

Knight, R. L., and D. N. Cole. 1995. Wildlife responses to recreationists. Pages 51–69 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreation: coexistence through management and research. Island Press, Washington, D.C., USA.

MacArthur R. A., R. H. Johnson, and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. Canadian Journal of Zoology 57:2010–2021.

Stockwell, C. A., and G. C. Bateman. 1991. Conflicts in national parks: a case study of helicopters and bighorn sheep time budgets at Grand Canyon. Biological Conservation 56:317–328.

USFS (U.S. Forest Service). 1996. Environmental assessment for outfitted and guided backcountry helicopter skiing on the Sawtooth National Forest. U.S. Forest Service, Ketchum Ranger District, Ketchum, Idaho, USA.

Watson, J. W. 1993. Responses of nesting bald eagles to helicopter surveys. Wildlife Society Bulletin 21:171–178.

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HARASSMENT OF WILDLIFE BY THE PETS OF WINTER RECREATIONISTS

Harassment of wildlife by the pets of winter recreationists is increasing. Harassment is defined as any activity of humans and their associated domestic animals that increase the physiological costs of survival or decrease the probability of successful reproduction of wild animals. As winter recreational use increases and as people continue to take pets with them on their winter trips, the problem will continue to grow. The literature suggests that the primary problem is dogs chasing deer, but dogs can chase other wildlife, and cats can kill birds and small mammals.

Harassment of wildlife by pets is primarily occurring on national forest lands in the Greater Yellowstone Area (GYA) as pets are not allowed off-leash in the national parks. The extent of the problem in the GYA is unknown at this time.

POTENTIAL PROBLEMS WITH PET HARASSMENT OF WILDLIFE

Pets both chase and kill wildlife (George 1974, Lowry and McArthur 1978). In a 1958 study, mule deer in Missouri were chased from their home ranges by dogs, including one chase that lasted 3.25 miles (Progulske and Baskett 1958). This study also stated that dogs were a negligible cause of direct mortality of deer under the conditions of the study. Bowers (1953), however, found that free-running dogs killed more deer than legal hunters during a two-month winter period in Virginia.

In Yellowstone National Park in the summer of 1989, a domestic dog chased and caught a mule deer buck and tore off the deer's lower mandible. Park rangers subsequently destroyed the deer.

Being chased by a domesticated pet can disrupt a wild animal's energetic balance. Geist (1971) stated that running increases an ungulate's need for food and that these animals can become stressed to the point that they require more energy than they are able to take in. Consequently, the animals must use body reserves. Pregnant animals suffer higher stress levels, causing some animals to abort. A controlled study in Virginia (Gavitt 1973) used dogs to intentionally chase deer. The study found no significant differences in fawns per doe survival rates between deer that were chased and deer that were not chased. The study also found no changes in home range and that no healthy deer were caught by dogs.

Even if a direct chase does not occur, domestic pets can increase stress on wildlife. MacArthur et al. (1982) found that the greatest increase in bighorn sheep heart rates occurred when the sheep were approached by humans with a dog.

The literature suggests that deer are the primary target of harassment by pets and that dogs are the primary problem. But, cats have been implicated in killing a snowshoe hare (Doucet 1973) as well as birds and small mammals.

It is possible for domestic pets to transmit diseases to wildlife. Canine distemper, a severe and highly contagious virus, can be transmitted to both canids and mustelids. Transmission is primarily by aerosol or by direct contact with infected individuals. Mortality rates from canine distemper vary between species and range from 20–100 percent (Wyoming Game and Fish Department 1982). Yellowstone National Park has had one wolf and one pine marten mortalities from canine distemper (Douglas Smith, personal communication). Parvovirus is also a disease concern. In Isle Royale National Park, 25 wolves died in two years from a parvovirus epidemic that was most likely introduced from a domestic dog (Jack Oelfke, personal communication). Transmission is only a problem in dogs that have not been properly vaccinated.

MANAGEMENT RECOMMENDATIONS

Visitor education has the most promise for mitigating this potential problem. Informing people of the potential problem and asking them to leash pets in critical deer winter range could reduce chasing of wildlife. Direct restrictions on pets in critical deer winter range could be applied if educational efforts are not effective.

LITERATURE CITED

Bowers, R. R. 1953. The free-running dog menace. Virginia Wildlife 14(10):5–7.

Doucet, G. T. 1973. House cat as predator of snowshoe hare. Journal of Wildlife Management 37(4):591.

Gavitt, J. D. 1973. Disturbance effect of free-running dogs on deer reproduction. Thesis, Virgina Polytechnical Institute and State University, Blacksburg, Virginia, USA.

Geist, V. 1971. Is big game harassment harmful? Oil Week June 14:12–13.

George, V. 1974. Domestic cats as predators and factors in winter shortages of raptor prey. Wilson Bulletin 86:384–396.

Lowry, D. A., and K. L. McArthur. 1978. Domestic dogs as predators on deer. Wildlife Society Bulletin 6:38–39.

MacArthur, R. A., V. Geist, and R. H. Johnson. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. Journal of Wildlife Management 46:351–358.

Progulske, D. R., and T. S. Baskett. 1958. Mobility of deer. Journal of Wildlife Management 22(2):184–192.

Wyoming Game and Fish Department. 1982. Diseases of wildlife in Wyoming, Second edition. Wyoming Game and Fish Department, Cheyenne, Wyoming, USA.

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EFFECTS OF SNOWMOBILING ACROSS OPEN WATER ON FISH AND WILDLIFE

Snowmobiling on open water involves a daring or, in some cases, intoxicated snowmobiler with a powerful machine who attempts to either make it across open water or to take a round trip on open water without submerging the snowmobile. If the snowmobile is submerged, the snowmobiler will hook onto it with a rope or chain and pull it out of the water using another snowmobile on the bank.

Snowmobiling on open water has the potential to affect water quality; aquatic species, such as invertebrates and trout; and riparian-dependent wildlife, specifically moose, furbearers, waterfowl (including trumpeter swans), and bald eagles.

This activity is currently not widespread in the Greater Yellowstone Area (GYA), but has occurred in a few isolated areas (the author has personal knowledge of the activity occurring on the Henrys Fork at Mack's Inn, Idaho, and D. Welch of the U.S. Forest Service has observed snowmobiles crossing open water on Island Park Reservoir). There is potential for this type of activity to increase because of its popularity in other parts of the country.

The most desirable waters for this activity are shallow ponds or shallow slow-moving streams with a gradually sloping bank where the machine can either exit or be retrieved if submerged. If the snowmobiler engages in this activity on a regular basis, it is desirable to choose locations near a facility where the wet snowmobiler can warm up and dry off.

Most waters in the GYA (lakes, ponds, and streams) are frozen throughout the winter period. However, some spring-fed streams, thermal waters, and areas where a stream empties into a lake or reservoir may remain open during part or all of the winter. Because the amount of open water is limited in the GYA during winter, it is critical to the survival of many wildlife species.

POTENTIAL EFFECTS

Snowmobiling on open water has the potential to pollute the water with snowmobile exhaust and spilled oil and/or gas, to stir up sediments on the bottom, to disturb winter-stressed fish and other aquatic wildlife, and to displace wildlife from important winter habitat. Bald eagles forage along open water, and waterfowl use open water for foraging and loafing during the winter. Moose use open water for foraging and travel and find security in the associated riparian vegetation. Several furbearers use open water and associated riparian vegetation during the winter.

A literature search produced little information on the effects of snowmobiling on open water. Adams (1975) found that lead and hydrocarbons from snowmobile exhaust were in the water at high levels during the week following ice-out in a Maine pond. Fingerling brook trout in the pond showed lead and hydrocarbon uptake. Stamina, as measured by the ability to swim against the current, was significantly less in trout exposed to snowmobile exhaust than in control fish. Gabrielsen and Smith (1995) found that fish stopped swimming in response to ground or sound vibration.

In the GYA, the Potential Opportunity Areas that will most likely be affected by snowmobiling on open water include:

(1) Destination areas
(2) Primary transportation routes
(12) Low-snow recreation areas

MANAGEMENT GUIDELINES

Agency managers need to be aware of the potential for snowmobile use on open water and that there are possible effects to water quality, fish, and wildlife. This activity is in defiance of common sense, and agencies should prohibit it on public land to avoid impacts to water quality, aquatic species, and riparian-dependent wildlife.

To maintain water quality, Bury (1978) suggests a shift to four-cycle engines in snowmobiles. Four-cycle engines produce less pollutants. Shea (1979) recommends that snowmobile trails be routed away from river courses to protect wintering swans.

LITERATURE CITED

Adams, E. S. 1975. Effects of lead and hydrocarbons from snowmobile exhaust on brook trout (*Salvalinus fontinalis*). Transactions of the American Fisheries Society 104(2):363–373.

Bury, Richard L. 1978. Impacts of snowmobiles on wildlife. Page 154 *in* Proceedings, 43rd North American Wildlife and Natural Resource Conference.

Gabrielsen, G. W., and E. N. Smith. 1995. Physiological responses of wildlife to disturbance. Pages 95–107 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreation: coexistence through management and research. Island Press, Washington, D.C., USA.

Shea. R. 1979. The ecology of trumpeter swans in Yellowstone National Park and vicinity. Thesis, University of Montana, Missoula, Montana, USA.

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APPENDIX I: IMPACTS OF WINTER RECREATION ON WILDLIFE IN YELLOWSTONE NATIONAL PARK: A LITERATURE REVIEW AND RECOMMENDATIONS

by

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March 20, 1997

Report requested by the Branches of Planning and Compliance, Natural Resources, and Resources Management and Visitor Protection, Yellowstone National Park, Wyoming.

About the Author:

Dr. Caslick was a summer seasonal ranger in Yellowstone for three summers, starting in 1951. He was a wildlife biologist and directed a wildlife research laboratory for the U.S. Fish and Wildlife Service for 13 years. His graduate degrees are from Cornell University, where he taught wildlife research and management techniques for 18 years. Since retiring from Cornell, he and Mrs. Caslick have been full-time volunteers in Yellowstone for the past eight winters.

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Foreword

Numerous studies have concluded that wildlife is a major component of the Yellowstone experience, and a major economic "draw" to the area.

As increasing pressures for development of visitor facilities and new modes of transportation evolve, early consideration of their potential effects on wildlife (including individual animals, animal populations, and associated ecological processes) become ever more important, if wildlife resources are to continue to be a major feature of Yellowstone.

The purpose of this report is to briefly summarize and evaluate the published research on winter-recreation impacts on wildlife, particularly as they apply to Yellowstone, and to provide recommendations. This may have immediate application in decision-making during the trade-off processes that inevitably must occur when balancing resource conservation with visitor enjoyment.

Procedure

Starting in November 1996, I used "A Review of Potential Effects of Winter Recreation on Wildlife in Grand Teton and Yellowstone National Parks: A Bibliographic Data Base" by L. E. Bennett, 1995, as a starting point for the literature review. We obtained the electronic bibliographic component assembled with the ProCite bibliographic software program. I read the 139-page hard copy including the 465-entry bibliography, and deleted from our consideration 200 entries such as field guides that appeared to have little or no particular relevance to Yellowstone.

Using this shortened bibliography, I read as many of the relevant publications as could be located in Yellowstone and made reprint requests to authors and publishers. I also searched the new ProCite Natural History Database in the Yellowstone Research Library, and other bibliographies on the topic kindly provided by others. The Montana State University Library had previously been searched by K. Legg of the Office of Planning and Compliance, YNP, who advised that a repeat of that search probably would not be productive.

During my literature research, 211 new literature citations were discovered that seemed to have potential relevance to Yellowstone. Many of the most pertinent new literature sources that I found were in the M.S. and Ph.D. theses in the Yellowstone Research Library. All of these 211 new literature citations were listed in "New Citations on Winter Recreation Effects on Wildlife, J. and E. Caslick, 1997, 22 pp.," a copy of which is attached as Appendix 1. These new citations were then integrated with our revised list of Bennett (1995) to form "Selected Literature Citations from Bennett 1995 and New Citations from Caslick 1997 on Winter Recreation Effects on Wildlife, J. and E. Caslick, 1997, 74 pp.," a copy of which is attached as Appendix II. The new citations were also added to the revised ProCite database, now on file at YCR.

I met with the Visitor Use Management (VUM) Planning Team's Wildlife Resource Impacts Work Group on December 17/96, January 31, and February 24/97, sought their suggestions, and provided members with copies of 10 pertinent articles, as well as a draft of the new citations listing.

During the literature review and excerpting process, I attempted to retain the authors' interpretations by excerpting quotations; much can be lost otherwise. A summary of these findings in the literature was prepared as a matrix entitled "Matrix of Winter Recreation Effects on Wildlife, J. and E. Caslick, 1997, 25 pp.," a copy of which is attached as Appendix III. Rather than presenting a matrix chart with numbers that refer to a separate bibliography, it seemed much more immediately useful to excerpt the most pertinent information in the matrix and show the authors/ dates, thus allowing the user a choice of searching out the complete article, or using my excerpt without having to chase out the reference.

I found no documented impacts to mid-size carnivores. Although Yellowstone is believed to help support a viable population of wolverines, and lynx may have been resident over time, there is less evidence of historic or present fisher populations (Anon., National Park Service 1995:78). However, concern about the possibility of denning disturbance of wolverines by winter recreationists in high-altitude cirques was discussed by biologists at a VUM meeting in Bozeman this winter. Visitor impacts on coyotes have not been located in the literature, although in Yellowstone coyotes have long been observed to frequent plowed roads, snowmobile trails, ski trails, and other human trails, sometimes have been illegally fed, and apparently some coyotes have learned that they may be fed by humans. No research on this topic is listed in the 1995 YCR Investigators' Annual Report, although this continues to be a management concern. In an ongoing study of the effects of the l988 fires on coyotes, adult mortality was found to be "very low and primarily due to vehicles and mountain lions." Nine coyotes were reported killed by vehicles in the park in 1995 (Anon., National Park Service 1995). Although about 20 adult mountain lions inhabit Yellowstone's northern range, no impacts by recreationists other than by hunters outside the park have been documented (pers. comm. K. Murphy, Feb. 1997).

I have not included effects on vegetation or soils in this report, because most winter recreationists in Yellowstone use established trails or roadways, with snowcover present.

Time and the obscurity of some references precluded my review of all articles whose titles appeared to have some relevance to Yellowstone. I've included some of these in the matrix that may well be worthwhile to obtain and review.

In general, I feel fairly comfortable about the extent of my review of this topic. More could be done, of course, and review of new literature on the topic should be ongoing, particularly the emerging bodies of literature on wildlife energetics and nutrition in winter, stresses induced by human activities (including roads), the importance of habitat corridors, stressed ecosystems, and the developing science of ecotourism.

Summary of Literature Review

Much of the literature on this topic dates from the 1970s, when snowmobiles were new on the winter scene. There was a flurry of related papers, particularly from the Midwestern states, where several snowmobile conferences were held at universities. Many of the publications appeared in conference proceedings, not in refereed journals, so many literature citations are anecdotal accounts rather than reports of well-designed research projects that have tested hypotheses and used “controls.” Reports sometimes conflicted with previous findings, but there was general agreement that winter recreation, particularly snowmobiling, had great potential for negatively impacting wildlife and wildlife habitats (particularly vegetation). Even in these early conferences, snowmobile manufacturers were urged by wildlife biologists, at least, to design machines that were quieter and less-polluting. Snowmobile-polluted snow and its effects on wildlife, fish, and other aquatic organisms have not been investigated in Yellowstone, although published accounts elsewhere began at least 24 years ago (see 8 literature citations on “Polluted Snow” in this report). This seems to be another topic that should have been researched here long ago, particularly since we probably experience a higher intensity of snowmobile use than anywhere else, and since our fish and wildlife resources are so highly concentrated and of such unique public value.

During the late 1970s and early 1980s, most of the publications on human impacts on wildlife dealt with impacts on nesting birds. Perhaps this is because such impacts are more readily evident and easier to quantify for birds than for mammals. Among birds, nesting shorebirds and waterfowl in refuges and parks were then the dominant topics. Later in the 1980s, literature began to be dominated by visitor effects on nesting bald eagles. Effects on ungulates began to be published as state game departments and the U.S. Forest Service became concerned. In 1985, Boyle and Samson published a benchmark bibliography of 536 references that identified 166 articles containing original data, and “reported that mechanized forms of recreation had the greatest impacts on wildlife, causing habitat disturbance, disrupting of animal behavior, noise pollution, and even direct mortality.” (Purdy et al. 1987:6). The pace of publication slowed as some organizations imposed visitor-use restrictions, in a preventative mode, perhaps recognizing the difficulty and expense of definitive research. This is largely the situation today, although there is a slight increase of interest (largely academic) in quantifying nutritional and energetic stresses as they relate to ungulates and endangered species. The most recent publications of note deal with these latter topics, and with techniques for classifying, evaluating, and mitigating visitor use impacts.

By far, the most comprehensive single reference on this topic is a new book by several specialists in this field, “Wildlife and Recreationists: Coexistence Through Management and Research,” by R.L. Knight and K.J. Gutzwiller, eds. (1995), Island Press, Washington, D.C., 372 pp. During this project, I contacted the publisher for copyright permission and provided copies of pertinent chapters to members of the VUM Planning Team’s Wildlife Resource Impacts Work Group. Twenty chapters with different authors address such topics as Factors that Influence Wildlife Responses to Recreationists, Physiological Responses of Wildlife to Disturbance, Recreational

Disturbance and Wildlife Populations, and Indirect Effects of Recreationists on Wildlife. I highly recommend this book to anyone interested the current state of this topic.

The published concern about direct and indirect effects of winter recreationists on wildlife has not diminished among wildlife researchers elsewhere. From the early and obvious effects of intentional snowmobile harassment on wintering concentrations of wildlife, particularly in the Midwestern and eastern U.S., interest soon (although slowly) turned to unintended effects of winter recreation on wildlife. As early as 1975, Severinghaus and Tullar of the New York State Conservation Department were using energy expenditure calculations to demonstrate that deer already pressed by winter conditions should not be further stressed by snowmobiles, and recommended that snowmobile trails should be at least 1/2 mile from winter concentrations of white-tailed deer. Winter harassment of deer by snowmobiles was reported as detrimental to their winter adaptations for energy conservation in New York and Minnesota (Moen 1976, 1978), and winter energetics considerations and calculations for ungulates have continued as highly important research topics reported in peer-reviewed journals and are continuing today. Some of this energetics research has very recently been conducted by others in Yellowstone (see DelGuidice et al. 1994, 1991, for bison and elk), and could be tied to research on the energy expenditures required for locomotion by ungulates (see Parker et al. 1984, for mule deer and elk), to result in meaningful implications for recreation impacts on wintering wildlife in Yellowstone. In fact, Parker et al. (1984) discussed management implications based on energy-costs of locomotion for mule deer and elk, when disturbed by winter recreationists, and they pointed out that “the additional energy drain on a wintering population on poor range may be an important factor in survival” (p. 486). I consider winter-energetics research to be the most meaningful direction for “pure” research to further clarify the extent to which winter recreationists are negatively affecting winter-stressed wildlife in Yellowstone. (See Recommendations for Research #2, below).

Documented Impacts

In Yellowstone

As early as 1981, effects of winter recreationists on the physical environment of Yellowstone were reported to include air and snow pollution by snowmobile exhaust, litter, noise pollution, and limited damage to soils and plants in portions of the Madison, Firehole, and Gibbon river valleys (Aune 1981).

My review of the literature leaves me with no doubt that winter recreation activities in Yellowstone have affected wildlife behavior and survival, including bison use of groomed snowmobile trails (Aune 1981), and groomed-trail effects on changes in bison movements, habitat use, distribution and calf survival (Meagher 1993); Yellowstone elk have been affected by cross-country skiers (Aune 1981; Cassirer et al. 1992), and in Yellowstone, snowmobiling or cross-country skiers have caused most trumpeter swans to fly (Shea 1979).

Elsewhere in Montana and Wyoming

Elsewhere in Montana and Wyoming, published literature documents that snowmobile use has impacted deer, elk and small mammals (Aasheim 1980), bald eagles (Shea 1975; Alt 1980; Harmata 1996), an avian scavenger guild including bald eagles and black-billed magpies (Skagen et al. 1991), elk (Aasheim 1980) and bighorn sheep (Berwick 1968). There is no apparent reason to expect that similar effects would not occur in Yellowstone, where winter conditions are generally more severe and the intensity of snowmobile usage is generally higher than elsewhere in Montana and Wyoming.

Recommendations for Management

Winter Weather Considerations

Winters in Yellowstone are generally more severe than in any of the areas where recreational impacts on wildlife have been studied. This imposes an immediate constraint on applying the results of research conducted elsewhere; Yellowstone winters likely impose greater stresses on wildlife, even before visitor-induced stresses are added. For example, snowmobile activity in the Midwestern states has been shown to result in white-tailed deer movements away from trails. The energy cost of such movement at Midwestern snowdepths and temperatures are likely to be much less than for a similar movement under Yellowstone winter conditions. This movement must also be considered in the contexts of energy replacement costs and the quality of the habitat to which deer must move—must they now move more than previously to meet their energy requirements?

Proximity to and Overlap of Road Systems, Critical Winter Habitats (thermally-influenced) and Recreation Activities (road, trails, developments).

In Yellowstone, as elsewhere, there is a general shift of wildlife to lower-elevation habitats during winter. These habitats often are the riparian habitats in which the road system has been constructed. Since snowmobiling in Yellowstone is presently restricted to these established roadways, there is an immediate conflict in land uses. We have built our roads and developed areas in important (and perhaps key) wildlife wintering habitats, thereby reducing wildlife carrying capacity of the park. Winter uses and groomed roads are new environmental factors in these traditional wintering grounds, and we have yet to learn if and how some wildlife species, guilds, or populations will be affected in the long term. Some immediate effects are apparent, including displacement of individual animals and small groups, and associated energy expenditures by wildlife that result from recreationist activities and the related support and maintenance activities of the park and park concessioners.

There can be little doubt that continued human activity and additional commercial developments in these riparian areas will continue to degrade and diminish winter wildlife habitats, through depletion of resources previously available to wintering wildlife. This has been the pattern of wildlife population declines world-wide; there is no rationale for expecting results to be different here. Yellowstone now has wildlife in relative abundance because of a relatively low rate of human exploitation of habitats, but the clock is ticking and the exploitation rate is rapidly increasing.

The challenge for park managers is to apply the brakes now to slow the exploitation rate. Enforcement of park regulations alone will likely not suffice. Managers must make aggressive use of new techniques that promise to assist resource conservation efforts while concurrently accommodating visitor use. The science of ecotourism shows promise in this regard and park managers should explore its literature, learn how its principles are being applied in park management elsewhere (Anderson 1993; Blangley & Wood 1993; deGroot 1983; Wallace 1993), and stay tuned for further developments. The management emphasis here must be on conservation, education, then visitor use, in that order of priority, if the wildlife values of this park are to be retained in the long-term.

1. Reduce Snowmobiling Impacts in Thermally-Influenced Habitats

In regard to wildlife in Yellowstone, I conclude from my literature review that the most pressing VUM issue is snowmobiling—not snowmobiling in general, but snowmobiling in and near thermally-affected wildlife habitats that are known to be unique and of critical value to wildlife in winter. This value to Yellowstone wildlife is not conjecture; it has been widely recognized and published about for many years, particularly in regard to elk (USDI/NPS 1990), bison (Meagher 1970), bald eagles (Alt 1980; Swenson 1986, USDI/NPS 1990, 1995), and trumpeter swans (Shea 1979; USDI/NPS 1990). The Matrix of Winter Recreation Effects on Wildlife and Selected Literature Citations. . . attached as Appendices III and II support this view. From my literature review, I conclude that there is now ample documentation to administratively close these thermally-influenced winter habitats, prohibiting winter use by private and commercial snowmachines, skiers, snowshoers, and hikers.

To increase protection of these thermally-influenced wildlife habitats in winter and to interrupt the existing network of groomed trails now known to be used by Yellowstone elk and moose (USDI/NPS 1990) and bison (Aune 1981; Meagher 1993), I therefore recommend that private and commercial snowmachine use be permitted in the park only as follows:

(1) Mammoth to Indian Creek Campground
(2) West Entrance to 7-mile Bridge
(3) South Entrance to Lewis Lake Campground
(4) East Entrance to Sylvan Lake (or Sylvan Pass).

To further reduce impacts on wildlife, over-snow administrative travel on other park roads should be restricted to the middle hours of daylight (*i.e.*, 10 a.m. to 4 p.m.) to avoid wildlife disturbance during their early morning and evening feeding periods.

During winter, processes that influence energy intake, rather than energy expenditure, have a much greater influence on the energy balances of ungulates (Hobbs 1989).

2. Discontinue the "Harmful vs. Beneficial" Dichotomy.

I recommend that VUM planners and managers in Yellowstone discontinue speculation about whether particular impacts are harmful or beneficial to wildlife. Where management's objective is to maintain natural processes and minimize the effects of humans, such value judgments are inappropriate and unproductive. Rather, the appropriate challenges seem to be detection of impacts, quantification thereof, timely decisions on priorities for mitigation activities, and implementation of those activities.

3. Initiate Visitor Use Management Trials and Monitor the Results.

From years of experience in wildlife research and management, I am aware of the tendency to call for more research and thereby postpone important decisions until research results are available. Certainly more research on the topic of this report would be useful, and recommendations for research are given in a later section of this report. But there is a recent development in methodology for tackling complex management issues that does not seem to be in use in Yellowstone. This is the approach called for by Dr. N. Christensen when he delivered the Leopold Lecture at Yellowstone's First Biennial Scientific Conference in 1991. He said, "ignorance will not provide a reprieve from managing" and that through viewing management plans as "working hypotheses that can be tested over time," the challenges can be overcome (Anon. 1992) (emphasis added). This idea had been previously suggested by MacNab (1983) and most recently by Knight and Gutzwiller (1995), who suggested that serial management experiments can be used to assess cause and effect relationships - such as visitor use impacts - using temporal and spatial controls, randomized designs, covariates, and adequate replication. Note that these are management experiments not intended to replace long-term research, but to initiate action programs that may be helpful, while awaiting research results.

In Yellowstone, we don't need to prove that specific human activities are impacting wildlife before we initiate management measures. Where there are indications that impacts may be occurring, managers could undertake experimental management measures to reduce/minimize/eliminate these effects, while carefully documenting the results of the experimental management program. This documentation would provide a basis for making decisions about visitor use management needs and possibly elucidate priorities for research.

4. Adopt Standardized Terminology for Classification of Impacts and Impact-Mitigation Techniques.

Visitor use management in Yellowstone should be based on the recognition that there is no such thing as the non-consumptive use of wildlife or other natural resources. Every use exacts a toll. This has been a published view for at least 20 years (Wilkes 1977; Weedin 1981).

VUM then becomes a series of decisions about:
(1) what is the toll?
(2) is the toll acceptable?
(3) if not, how can the toll be reduced?

To classify impacts on wildlife, I recommend the scheme developed by Purdy et al. (1987) for the National Wildlife Refuges; these impacts are:
Direct Mortality
Indirect Mortality
Lowered Productivity
Reduced Use of Refuge (Park for YNP)
Reduced Use of Preferred Habitat
Aberrant Behavior/Stress

The classifications could as well serve as standards for evaluating visitor impacts on wildlife, and as standards evaluating the effectiveness of VUM measures in Yellowstone. The suggested measures of controlling visitor-related impacts on refuges (Visitor Education, Zoning, Restrictions on Activities, Law Enforcement, and various combinations of these measures) are all applicable here and could as well serve as a classification scheme for YNP mitigation efforts.

5. Consider Non-Visitor Impacts

The VUM plan should address impacts to wildlife that result from tour groups, scientists, educational activities (NPS, Yellowstone Institute, school groups, concessioner activities and NPS administrative activities) (see White and Bratton 1980). Mitigation techniques - initially evaluated as management trials - might include both temporal and spatial components. For example, during the period between official close of the park for the winter season and opening for the summer season, the park could restrict administrative travel on the previously groomed snowmobile routes to that required for official emergency travel only. Whenever possible, restrict even this emergency use to the mid-daylight hours (*i.e.*, 10 a.m. to 4 p.m.) to avoid disruption of the major feeding times for wildlife, during these critical weeks in wildlife survival.

6. Consider Sacrifice Areas

In defining VUM Potential Opportunity Areas, there seems to be an underlying assumption that it is desirable to distribute recreation throughout the greater Yellowstone area (p. 1, para. 3, Feb. 1996 draft). I recommend that this basic assumption be reconsidered to include the possibility that small sacrifice areas and large administrative closures may be ecologically preferable. For example, in Yellowstone, it may be preferable to dedicate a small area of low-quality wildlife habitat to heavy-use snowmobiling if, in so doing, a large thermal area of high-quality wildlife habitat is thereby protected.

7. Convene a Panel of Outside Specialists

Convene a panel of outside specialists on winter recreation effects on wildlife, specialists on human dimensions in wildlife management, and specialists in conflict resolution in resource management, to address the topic “Management of Winter Recreation Impacts on Wildlife in Yellowstone.” Provide participants with copies of this report and other pertinent information, including NPS policy, prior to the meeting. Charge them with making recommendations for both immediate and long-term visitor management, and related short-term and long-term research projects and priorities. I can provide names of some potential participants. I recognize that suggestion of a panel of outside experts may strike fear in the hearts of some administrators, but recommendations may be accepted or rejected, and traditional public hearings in gateway communities cannot be expected to provide expertise or consensus. In fact, Dr. Kellert of Yale University, a specialist in public attitudes and the human dimensions of resource management, has published his view that public hearings are confrontational procedures that tend to harden positions and foster polarization. Like lake trout control, visitor use management here is a complex issue requiring input from specialists.

8. Prepare an EIS

Based upon the published effects of winter recreation on wildlife in Yellowstone that are documented here, and possibly including other air and water quality concerns in Yellowstone, promptly initiate preparation of an Environmental Impact Statement (EIS) on Winter Visitor Use in Yellowstone. In the EIS, include alternatives of “no snowmobiling” as well as alternatives for additional spatial and temporal restrictions on over-snow travel, as outlined above. Include consideration of alternative modes of transport for winter visitor enjoyment of park resources. Suspend further improvement and development of facilities to accommodate winter visitors (including Old Faithful Snowlodge), pending outcome of the NEPA process.

Recommendations for Research

The World Heritage Committee, an international panel of conservationists from countries that signed the World Heritage Convention in 1973, met in Yellowstone in 1995 and voted to add Yellowstone to a list of "endangered" sites that are "of universal value to mankind." The growing number of park visitors was one of the factors upon which this decision was based (Anon. 1996: 10).

Although Yellowstone has a Winter Use Resource Team, as of 1995 the team apparently had not decided whether increasing winter use was harmful to wildlife: "Increasing winter use may be harmful for wildlife . . ." (Anon. 1996:18) (emphasis added). Information gathered by the team in 1995 included a winter recreation and wildlife literature search by the University of Wyoming for Grand Teton National Park (Bennett 1995).

Winter visitor impacts were not a major area of emphasis reported in the Natural Resources Programs section of the Yellowstone Center for Resources 1995 Annual Report (Anon. 1996a). Although the 1990 Winter Use Plan Environmental Assessment for Yellowstone NP/Grand Teton NP/Rockefeller Parkway identified the need for more research on wildlife to determine "if visitor is causing impacts to wildlife" (USDI 1990:40) (emphasis added), Yellowstone's 1995 Investigators' Annual Report shows that no such studies have been initiated or currently are underway; the only projects listed as "visitor impacts" studies are a study of backcountry campsite use on conifer forest structure (Montana State University) and a study of human collection of artifacts scattered in a campground (University of Nebraska) (Anon. 1996b). There are no studies of visitor impacts on wildlife.

1. Actively Seek Outside Funding

It seems incredulous that so little research or management attention has been given or is now being given to this topic in this park. I therefore recommend that Yellowstone become pro-active in seeking outside funding from NSF and private sources such as the Rockefeller Foundation to support a well-planned research program that is coordinated with management efforts, and aimed at further clarifying visitor use/wildlife welfare relationships in this park. Invite park critics and others interested in this topic to financially support this new effort through the usual legislative processes and through direct contributions earmarked for this purpose.

2. Invite Research Proposals on Specific Topics

Invite research proposals from universities and others and prioritize funding to support those projects that address the most immediate needs of park management. Give highest priority to short-term projects that evaluate visitor use management strategies and to long-term projects that emphasize winter nutrition and energy budgets of wildlife, stress effects, survival strategies, and the modeling of these factors for population viability analyses. Focus on critical periods, critical habitats, synergistic effects and cumulative effects for wildlife present in Yellowstone, in winter.

Related studies such as that of Henry (1980), who examined relationships between visitor use and capacity for Kenya's Amboseli National Park, as a Ph.D. thesis, should also be encouraged and supported.

Thank you for the opportunity to review and summarize this literature, prepare this report, and make recommendations that I hope will be useful. I have appreciated the interest and support of the Yellowstone staff during completion of this project.

Attachments: 3

Appendix I

NEW CITATIONS ON WINTER RECREATION EFFECTS ON WILDLIFE

J. and E. Caslick

Resource Management, YCR

Yellowstone Park, WY 82190

March 1997

These are literature citations that were not included in Bennett, L.E. 1995. A review of potential effects of winter recreation on wildlife in Grand Teton and Yellowstone National Parks: a bibliographic data base. Univ. of Wyo. Coop. Fish & Wildlife Research Unit, Laramie. 108 pp.

1. Alt, K. L. ECOLOGY OF THE BREEDING BALD EAGLE AND OSPREY IN THE GRAND TETON-YELLOWSTONE NATIONAL PARKS COMPLEX. M. S. thesis. Univ. of Montana. 95 pp. 1980.
Note: new.
2. Anderson, D. L. A WINDOW TO THE NATURAL WORLD: THE DESIGN OF ECOTOURISM FACILITIES. In Ecotourism: A Guide for Planners and Managers, eds. K. Lindberg and D. E. Hawkins, 116-153. North Bennington, Vermont: The Ecotourism Society. 1993.
Note: new.
Emphasis on design to reduce environmental impacts and enhance visitors' satisfaction and awareness of the environment.
3. Anderson, S. H. RECREATIONAL DISTURBANCE AND WILDLIFE POPULATIONS. In R. L. Knight and K. J. Gutzwiller, eds. Wildlife and Recreation: Coexistence Through Management and Research. Island Press. Washington, D.C. 1995.
Note: new.
4. Anthony, A. and E. Ackerman. EFFECTS OF NOISE ON THE BLOOD EOSINOPHIL LEVELS AND ADRENALS OF MICE. Journal of the Acoustical Society of America 27(6):1144-1149. 1955.
Note: new.
5. Anthony, R. G., R. J. Steidl, and K. McGarigal. RECREATION AND BALD EAGLES IN THE PACIFIC NORTHWEST. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 223-241. Island Press. Washington, D.C. 1995.
Note: new.
Human disturbance is most serious for eagles that depend on large fish or mammal carcasses as their major food source.
6. Baldwin, F. M. THE OFF-ROAD VEHICLE AND ENVIRONMENTAL QUALITY; A REPORT ON THE SOCIAL AND ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES, PARTICULARLY SNOWMOBILES, WITH SUGGESTED POLICIES FOR THEIR CONTROL. The Conservation Foundation, Washington, D.C. 52 pp. 1970.
Note: new.
Clearly the effective way to protect fish and wildlife is not by restricting hunting or harassment alone, but by banning these vehicles from important habitats (p.25).
7. Baldwin, M. F. and D. H. Stoddard, Jr. THE OFF-ROAD VEHICLE AND ENVIRONMENTAL QUALITY: AN UPDATED REPORT ON THE SOCIAL AND ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES, PARTICULARLY SNOWMOBILES, WITH SUGGESTED POLICIES FOR THEIR CONTROL. 2nd ed. Conservation Foundation. Washington, D.C. 61 pp. 1973.
Note: new.
8. Bayfield, N. G. SOME EFFECTS OF WALKING AND SKIING ON VEGETATION AT CAIRNGORM. J. Applied Ecology 7:469-485. 1970.
Note: new.
9. Beier, P. DETERMINING MINIMUM HABITAT AREAS AND HABITAT CORRIDORS FOR COUGARS. Conser. Biol. 7:94-108. 1993.
Note: new.

10. Bennett, L. E. A REVIEW OF POTENTIAL EFFECTS OF WINTER RECREATION ON WILDLIFE IN GRAND TETON AND YELLOWSTONE NATIONAL PARKS: A BIBLIOGRAPHIC DATABASE. Final Report. Mimeo. Sponsored by U.S. National Park Service in cooperation with Univ. of Wyoming Cooperative Fish and Wildlife Research Unit, Laramie. 141 pp. 1973.
Note: new.

11. Berry, K. H. A REVIEW OF THE EFFECTS OF OFF-ROAD VEHICLES ON BIRDS AND OTHER VERTEBRATES. In: Management of Western Forests and Grasslands for Nongame Birds. Workshop Proceedings. U.S. For. Srv., Gen. Tech. Rep. INT-86, pp. 451-467. 1980.
Note: new.

12. Bess, F. H. THE EFFECT OF SNOWMOBILE NOISE ON THE HEARING MECHANISM. Proceedings of the 1971 Snowmobile and Off-Road Vehicle Research Symposium. Sponsored by the Dept. of Park and Recreation Resources, Michigan State University, East Lansing, Michigan. 1971.
Note: new.

13. Bissell, L. P. THE SOCIAL AND POLITICAL IMPACT OF SNOWMOBILES. In: Proceedings 3rd International Snowmobile Congress, Portland, Maine. pp.58-62. 1970.
Note: new.

14. Bjarvall, A. NORTH AMERICAN STUDIES ON THE EFFECTS OF SNOWMOBILES ON FAUNA. Flora Fauna. 1974.
Note: new.

15. Blangley, S. and M. E. Wood. DEVELOPING AND IMPLEMENTING ECOTOURISM GUIDELINES FOR WILDLANDS AND NEIGHBORING COMMUNITIES. In: Ecotourism: A Guide for Planners and Managers, K. Lindberg and D. E. Hawkins, eds., pp. 32-54. North Bennington, Vermont; The Ecotourism Society. 1993.
Note: new.

16. Bollinger, J. G., O. J. Rongstad, A. Soom, and R. G. Eckstein. SNOWMOBILE NOISE EFFECTS ON WILDLIFE. 1972-1973 report. Engineering Exp. Sta., Univ. of Wisconsin, Madison. 85pp. 1973.
Note: new.

17. Boucher, J. and T. A. Tattar. SNOWMOBILE IMPACT ON VEGETATION. Forest Notes 120:27-28. 1974.
Note: new.

18. Bowles, A. E. RESPONSES OF WILDLIFE TO NOISE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 109-156. Island Press. Washington, D.C. 1995.
Note: new.

19. Bowles, A. B. Tabachnick, and S. Fidell, eds. REVIEW OF THE EFFECTS OF AIRCRAFT OVERFLIGHTS ON WILDLIFE. National Park Service, Report No. 7500. 373 pp. 1991.
Note: new.
This three-volume compilation, with bibliography, reviews various studies conducted on the effects of aircraft noise on wildlife. A summary draws conclusions. Includes general disturbance factors.

20. Boyce, M. S. POPULATION VIABILITY ANALYSIS. Annu. Rev. Ecol. Syst. 23:481-506. 1992.
Note: new.

21. Boyle, S. A. and F. B. Samson. EFFECTS OF NONCONSUMPTIVE RECREATION ON WILDLIFE: A REVIEW. Wildlife Society Bull. 13(2):110-116. 1985.
Note: new.
A literature review of 536 references which showed negative effects for most types of recreational activity. Suggests four management alternatives including “sacrifice” areas.

22. Boyle, S. A. and F. B. Samson. EFFECTS OF NONCONSUMPTIVE RECREATION ON WILDLIFE: A REVIEW. Wildl. Soc. Bull. 13:110-116. 1985.
Note: new.

23. Burkey, T. V. EXTINCTION IN NATURE RESERVES: THE EFFECT OF FRAGMENTATION AND THE IMPORTANCE OF MIGRATION BETWEEN RESERVE FRAGMENTS. Oikos 55:75-81. 1989.
Note: new.

24. Bury, R. EFFECTS OF OFF-ROAD VEHICLES ON DESERT VERTEBRATES. Bulletin of the Ecological Society of America 56(2):40. 1975.
Note: new.

25. Bury, R. B., R. A. Luckenbach, and S. D. Busak. EFFECTS OF OFF-ROAD VEHICLES ON VERTEBRATES IN CALIFORNIA. USDI Fish & Wildlife Service. 1977.
Note: new.
Compared 8 paired sites. ORV use areas had significantly fewer species of vertebrates, reduced numbers of individuals and lower reptile and small mammal biomass. Censuses also showed decreased diversity, density, and biomass estimates of breeding birds in ORV used areas.

26. Cannon, H. L. and J. M. Bowles. CONTAMINATION OF VEGETATION BY TETRAETHYL LEAD. Science 137:765-766. 1988.
Note: new.

27. Cassirer, E. F. RESPONSES OF ELK TO DISTURBANCE BY CROSS-COUNTRY SKIERS IN NORTHERN YELLOWSTONE NATIONAL PARK. M. S. Thesis, Univ. of Idaho, Moscow. 101 pp. 1990.
Note: new.

28. Chappel, R. W. and R. J. Hudson. PREDICTION OF ENERGY EXPENDITURES BY ROCKY MOUNTAIN BIGHORN SHEEP. Can. J. Zool. 58:1908-1912. 1980.
Note: new.

29. Cole, D. N. and P. B. Landres. INDIRECT EFFECTS OF RECREATIONISTS ON WILDLIFE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 183-202. Island Press. Washington, D.C. 1995.
Note: new.

30. Cole, D. L. and R. L. Knight. WILDLIFE PRESERVATION AND RECREATIONAL USE: CONFLICTING GOALS OF WILDLIFE MANAGEMENT. Tran. N. Am. Wildl. Nat. Res. Conf. 56:233-237. 1991.
Note: new.

31. Cole, G. F. GRIZZLY BEAR - ELK RELATIONSHIPS IN YELLOWSTONE NATIONAL PARK. J. Wildl. Mgmt. 36(2):556-561. 1972.
Note: new.

32. Cooke, A. S. OBSERVATIONS ON HOW CLOSE CERTAIN PASSERINE SPECIES WILL TOLERATE AN APPROACHING HUMAN IN RURAL AND SUBURBAN AREAS. Biological Conservation 18:85. 1980.
Note: new.

33. Craighead, J. J., G. Atwell and B. W. O'Gara. ELK MIGRATIONS IN AND NEAR YELLOWSTONE NATIONAL PARK. Wildl. Monog. 29. 48 pp. 1972.
Note: new.

34. Davy, B. A. and B. H. Sharp. CONTROL OF SNOWMOBILE NOISE. Environmental Protection Agency, Ofc. of Noise Abatement and Control. Springfield, VA. 1984.
Note: new.

35. deGroot, R. W. TOURISM AND CONSERVATION IN THE GALAPAGOS. Biological Conservation 26:291-300. 1983.
Note: new.

36. Despain, D. D. Houston, M. Meagher, and P. Schullery. WILDLIFE IN TRANSITION: MAN AND NATURE ON YELLOWSTONE'S NORTHERN RANGE. Roberts Rinehart. Boulder, Colo. 142 pp. 1986.
Note: new.

37. Dice, E. F. EFFECTS OF SNOWMOBILING ON ALFALFA, TREES (PINUS RESINOSA, PINUS BANKSIANA) AND SOIL BACTERIA. Ext. Bull. Michigan State Coop. Ext. Serv. East Lansing, Mich. 1976.
Note: new.

38. Dixon, K. R. and J. A. Chapman. HARMONIC MEAN MEASURE OF ANIMAL ACTIVITY AREAS. Ecology 6:1040-1044. 1980.
Note: new.

39. Doan, K. H. EFFECT OF SNOWMOBILES ON FISH AND WILDLIFE RESOURCES. Int. Assoc. Game Fish Conservation Commissioners Convention 60:97-103. New York. 1970.
Note: new.

40. Driver, B. L. and P. J. Brown. THE OPPORTUNITY SPECTRUM CONCEPT AND BEHAVIORAL INFORMATION IN OUTDOOR RECREATION SUPPLY INVENTORIES: A RATIONALE. In: Integrated Inventories and Renewable Natural Resources. Proceedings of the Workshop, eds. Lund, H.G. et al., 24-31. General Tech. Report RM-55. Fort Collins, Colo. U.S. Dept. Agric., Forest. 1978.
Note: new.

41. Dufour, P. EFFECTS OF NOISE ON WILDLIFE AND OTHER ANIMALS. Memphis State University, for United States Environmental Protection Agency, NTID 300.5. 1971.
Note: new.
Data for domestic and laboratory animals was extrapolated for wildlife. Potential impacts included masking of signals and calls. Chronic exposure could result in physiological and behavioral changes. Effects would most likely be cumulative.

42. Dunning, J. B., B. J. Danielson, and H. R. Pulliam. ECOLOGICAL PROCESSES THAT AFFECT POPULATIONS IN COMPLEX LANDSCAPES. Oikos 65:169-175. 1992.
Note: new.
43. Eckstein, R. G. and O. J. Rongstad. EFFECTS OF SNOWMOBILES ON THE MOVEMENTS OF WHITE-TAILED DEER IN NORTHERN WISCONSIN. Proc. Midwest Fish and Wildl. Conf. 35-39. 1973.
Note: new.
44. Elgmark, K. and A. Langeland. POLLUTED SNOW IN SOUTHERN NORWAY DURING WINTERS 1968-1971. Environ. Pollution 4:41-52. 1973.
Note: new.
45. Enger, P. S. , H. E. Karlsen, F. R. Knudsen, and O. Sand. DETECTION AND REACTION OF FISH TO INFRASOUND. ICES Marine Sciences Symposia 196:108-112. 1993.
Note: new.
46. Erlich, P. R. EXTINCTION: WHAT IS HAPPENING NOW AND WHAT NEEDS TO BE DONE. In: Dynamics of Extinction, D. K. Elliott, ed., pp. 157-164. John Wiley and Sons, New York. 1986.
Note: new.
47. Fahrig, L. and G. Merriam. HABITAT PATCH CONNECTIVITY AND POPULATION SURVIVAL. Ecology 66:1762-1768. 1985.
Note: new.
48. Fay, R. R. HEARING IN VERTEBRATES: A PSYCHOPHYSICS DATABOOK. Hill-Fay Associates. Winnetka, Ill. 621 pp. 1988.
Note: new.
49. Ferguson, M. A. D. and L. B. Keith. INFLUENCE OF NORDIC SKIING ON DISTRIBUTION OF MOOSE AND ELK IN ELK ISLAND NATIONAL PARK, ALBERTA. Can. Field-Nat. 99:69-78. 1982.
Note: new.
50. Ferrin, R. S. and G. P. Coltharp. LEAD EMISSIONS FROM SNOWMOBILES AS A FACTOR IN LEAD CONTAMINATION OF SNOW. Proceedings of the Utah Academy of Science, Arts and Letters 51(1):116-118. 1974.
Note: new.
51. Fletcher, J. L. and R. G. Busnel, eds. EFFECTS OF NOISE ON WILDLIFE. Academic Press, Inc., New York. 1978.
Note: new.
Several papers, including a symposium on the effects on wildlife, quantifying the acoustic dose when determining the effects of noise on wildlife, and a perspective of government and public policy regarding noise and animals.
52. Foin, T. C., E. O. Garton, C. W. Bowen, J. M. Everingham, R. O. Schultz, and B. Holton, Jr. QUANTITATIVE STUDIES OF VISITOR IMPACTS ON ENVIRONMENTS OF YOSEMITE NATIONAL PARK, CALIFORNIA, AND THEIR IMPLICATIONS FOR PARK MANAGEMENT POLICY. Journal of Environmental Management 5:1-22. 1977.
Note: new.

53. Foresman, C. L., D. K. Ryerson, R. F. Johannes, W. H. Paulson, R. E. Rand, G. H. Tenpas, D. A. Schlough, and J. W. Pendleton. EFFECTS OF SNOWMOBILE TRAFFIC ON NON-FOREST VEGETATION: SECOND REPORT. School of Natural Resources, Univ. of Wisconsin, Madison, Wisc. 1973.
Note: new.
54. Gabrielsen, G. W. and E. N. Smith. PHYSIOLOGICAL RESPONSES OF WILDLIFE TO DISTURBANCE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 95-107. Island Press. Washington, D.C. 1995.
Note: new.
55. Garrott, R. A. G. White, R. M. Bartman, L. H. Carpenter, and A. W. Alldredge. MOVEMENTS OF FEMALE MULE DEER IN NORTHWEST COLORADO. Journal of Wildl. Mgmt. 51(3). 1987.
Note: new.
Migration was strongly correlated to winter severity. Demonstrated strong fidelity to summer and winter ranges. Fidelity of individual movement patterns is long term, possibly for life.
56. Geist, V. BEHAVIOR. In: Big Game of North America: Ecology and Management, J. L. Schmidt and D. C. Gilbert, eds., pp. 283-296. Stackpole Books. Harrisburg, Penn. 494 pp. 1978.
Note: new.
57. Gilpin, M. E. SPATIAL STRUCTURE AND POPULATION VIABILITY. In: Viable Populations for Conservation, M. E. Soule, ed., pp. 124-139. Cambridge University Press. 1987.
Note: new.
58. Gipson, P. S. ABORTION AND CONSUMPTION OF FETUSES BY COYOTES FOLLOWING ABNORMAL STRESS. Southwestern Naturalist 21:558-559. 1970.
Note: new.
59. Graefe, A. R., F. R. Kruss, and J. J. Vaske. VISITOR IMPACT MANAGEMENT: THE PLANNING FRAMEWORK. National Parks and Conservation Association. Washington, D.C. 105 pp. 1990.
Note: new.
60. Graefe, A. R., F. R. Krass, and J. J. Vaske. VISITOR IMPACT MANAGEMENT. Vols. I and II. National Parks and Conservation Association. Washington, D.C. 1990.
Note: new.
61. Graul, W. D. and G. C. Miller. STRENGTHENING ECOSYSTEM MANAGEMENT APPROACHES. Wildl. Soc. Bull. 12:282-289. 1984.
Note: new.
62. Gray, J. A. PSYCHOLOGY OF FEAR AND STRESS, 2ND ED. Cambridge University Press. New York. 1987.
Note: new.
63. Greer, T. ENVIRONMENTAL IMPACT OF SNOWMOBILES: A REVIEW OF THE LITERATURE. Univ. of Oregon, Portland, Ore. 1979.
Note: new.

64. Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. AN ECOSYSTEM PERSPECTIVE OF RIPARIAN ZONES. BioScience 41:540-551. 1991.
Note: new.
65. Greller, A. M., et al. SNOWMOBILE IMPACT ON THREE ALPINE TUNDRA PLANT COMMUNITIES. Environmental Conservation 1(2):101-110. 1974.
Note: new.
66. Gutzwiller, K. J. RECREATIONAL DISTURBANCE AND WILDLIFE COMMUNITIES. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 169-181. Island Press. Washington, D.C. 1995.
Note: new.
67. Gutzwiller, K. J. RECREATIONAL DISTURBANCE AND WILDLIFE COMMUNITIES. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 169-181. Island Press. Washington, D.C. 1995.
Note: new.
68. Hagen, A. and A. Langeland. POLLUTED SNOW IN SOUTHERN NORWAY AND THE EFFECT OF THE MELTWATER ON FRESHWATER AND AQUATIC ORGANISMS. Environ. Pollution 5:45-57. 1973.
Note: new.
69. Haines, H. E. J. SNOWMOBILES IN YELLOWSTONE: BIOMASS ALTERNATIVES TO REDUCE POLLUTION. Montana Dept. of Environmental Quality. Survey of Visitor Impact on Wildlife. Curtis Canyon Area, National Elk Refuge, Jackson, Wyo. 1984.
Note: new.
70. Hammitt, W. E. and D. N. Cole. WILDLAND RECREATION: ECOLOGY AND MANAGEMENT. John Wiley and Sons. New York.
Note: new.
71. Hare, C. T. and K. J. Springer. SNOWMOBILE ENGINE EMISSIONS AND THEIR IMPACT. Office of Air and Water Programs, Environmental Protection Agency, Southwest Research Institute. San Antonio, Tex. 1974.
Note: new.
72. Harris, L. D. and P. B. Gallagher. NEW INITIATIVES FOR WILDLIFE CONSERVATION: THE NEED FOR MOVEMENT CORRIDORS. In: Conservation Biology: The Theory and Practice of Nature Conservation, Preservation, and Management, P. L. Fiedler and S. K. Jain, eds., pp. 197-237. Chapman and Hall. New York. 1989.
Note: new.
73. Harrison, R. T. PREDICTING SNOWMOBILE ACOUSTIC IMPACT ON RECREATIONISTS. U. S. For. Ser. Equp. Dev. Center, ED&T Project No. 9227. San Dimas, Calif. 1980.
Note: new.
74. Hartmata, A. R. GREATER YELLOWSTONE BALD EAGLE MANAGEMENT PLAN. Greater Yellowstone Bald Eagle Working Group, Wyo. Game and Fish Dept., Lander, Wyo. 47 pp. 1996.
Note: new.

75. Hendee, J. C., G. H. Stankey, and R. C. Lucas. WILDERNESS MANAGEMENT. Misc. Publ. No. 1365. USFS, Dept. of Agric. 38 pp. 1978.
Note: new.

76. Henry, W. RELATIONSHIPS BETWEEN VISITOR USE AND CAPACITY FOR KENYA'S AMBOSELI NATIONAL PARK. Ph.D. Dissertation. Fort Collins, Colorado: Colorado State University. 1980.
Note: new.

77. Horney, R. L. SNOWMOBILING: GUIDELINES, ENVIRONMENTAL IMPACT, LEGISLATION, PROGRAMMING. National Recreation and Park Association. Washington, D.C. 1970.
Note: new.

78. Hudson, R. J. and R. J. Christopherson. MAINTENANCE METABOLISM. In: Bioenergetics of Wild Herbivores, R. J. Hudson and R. G. White, eds. CRC Press. Boca Raton, Fla. 314 pp. 1986.
Note: new.

79. Irwin, L. and J. Peek. RELATIONSHIP BETWEEN ROAD CLOSURES AND ELK BEHAVIOR IN NORTHERN IDAHO. University of Idaho and USDA Forest Service, Technical Report. 1979.
Note: new.

80. Ittner, R. D., D. R. Potter, J. K. Agee, and S. Anschell, eds. Conf. Proceedings: RECREATIONAL IMPACTS ON WILDLANDS. U. S. For. Serv. and U. S. Natl. Park Serv., R-6-001. Seattle, Wash. 341 pp. 1979.
Note: new.

81. Jacobsen, N. K. ALARM BRADYCARDIA IN WHITE-TAILED DEER FAWNS. Jour. of Mammalogy 60:343-349. 1979.
Note: new.
The near approach of humans will cause newborn fawns to drop to the ground. After 2 weeks old, the same stimulus will cause them to run.

82. Jarvinen, J. A. and W. D. Schmidt. SNOWMOBILE USE AND WINTER MORTALITY OF SMALL MAMMALS. In: Proceedings of the 1971 Snowmobile and Off the Road Vehicle Research Symposium, M. Chubb, ed., pp. 130-140, Tech. Rep. No. 8, Recreation Research and Planning Unit, Dept. Park and Recreation Resour. Michigan State Univ., East Lansing. 196 pp. 1971.
Note: new.
Study area: Minnesota. Used traps. Meadow vole, short-tailed shrew, white-footed mouse, ground squirrel, masked shrew and spotted skunk. Study showed increased mortality of small mammals, destroyed subnivean air spaces. Also a possibility of toxic air trapped in snow. Even conservative levels of snowmobiling on trails is destructive to wintering small mammals.

83. Johnson, T. H. RESPONSES OF BREEDING PEREGRINE FALCONS TO HUMAN STIMULI. In: Proc. Southwest Raptor Management Symposium and Workshop, Gilinski et al., eds. National Wildlife Federation. Washington, D.C. 1988.
Note: new.

84. Keddy, P. A., A. J. Spaovld, and C. J. Keddy. SNOWMOBILE IMPACT ON OLD FIELD AND MARSH VEGETATION IN NOVA SCOTIA, CANADA: AN EXPERIMENTAL STUDY. Environmental Management 3:409-415. 1979.
Note: new.
85. Keller, S. R. and J. K. Berry. A BIBLIOGRAPHY OF HUMAN/ANIMAL RELATIONS. Univ. Press of America. Lanham, MD. 1985.
Note: new.
86. King, M. M. and G. W. Workman. RESPONSE OF DESERT BIGHORN SHEEP TO HUMAN HARASSMENT: MANAGEMENT IMPLICATIONS. Transactions of the North American Wildlife and Natural Resources Conference 51:74-85. 1986.
Note: new.
87. Kirby, R. E. IMPACT OF HUMAN ACTIVITY UPON WILDLIFE AND WILDLIFE HABITAT. Statement of Work, Office Info. Transfer, Res. and Develop., U. S. Fish and Wildl. Serv. 3 pp. 1985.
Note: new.
88. Kirkpatrick, C. M., ed. PROCEEDINGS: WILDLIFE AND PEOPLE. Dept. For. Nat. Resour., Purdue Univ., Lafayette, Ind. 191 pp. 1985.
Note: new.
89. Knight, R. L. and S. K. K. Skagen. EFFECTS OF RECREATIONAL DISTURBANCE ON BIRDS OF PREY: A REVIEW. In: Proceedings of the Southwest Raptor Management Symposium and Workshop, L. Glinski et al., eds., pp. 355-359. National Wildlife Federation. Washington, D.C. 1988.
Note: new.
90. Knight, R. L. and D. N. Cole. FACTORS THAT INFLUENCE WILDLIFE RESPONSES TO RECREATIONISTS. In: Wildlife and Recreationists: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 71-79. 1995.
Note: new.
91. Knight, R. L. and K. J. Gutzwiller, eds. WILDLIFE AND RECREATIONISTS: COEXISTENCE THROUGH MANAGEMENT AND RESEARCH. Island Press. Washington, D.C. 372 pp. 1995.
Note: new.
Physiological and psychological responses, indirect effects, management strategies, case histories, ethics, historical perspectives.
92. Knight, S. K. and R. L. Knight. VIGILANCE PATTERNS OF BALD EAGLES FEEDING IN GROUPS. Auk 103:263-272. 1986.
Note: new.
93. Kopischke, E. D. EFFECTS OF SNOWMOBILE ACTIVITY ON THE DISTRIBUTION OF WHITE-TAILED DEER IN SOUTH CENTRAL MINNESOTA. Dept. Nat. Res. Game Research Proj. Rept. 1972.
Note: new.

94. Krueger, C. D. J. Decker, and T. A. Gavin. A CONCEPT OF NATURAL RESOURCE MANAGEMENT: AN APPLICATION TO UNICORNS. Trans. Northeast Sect. Wildl. Soc. 43:50-56. 1986.
Note: new.
A simplified, idealized conceptual model for resource management.

95. Kugler, B. A. and D. S. Barber. A METHOD FOR MEASURING WILDLIFE NOISE EXPOSURE IN THE FIELD (Abstract). Journ. of the Acoustical Society of America 93(4):2378. 1993.
Note: new.

96. Kuss, F. R., A. R. Graefe, and J. J. Vaske. VISITOR IMPACT MANAGEMENT: A REVIEW OF RESEARCH. National Parks and Conservation Association. Washington, D.C. 362 pp. 1990.
Note: new.

97. Lacey, R. M., R. S. Baran, W. D. Severinghaus, and D. J. Hunt. EVALUATION OF LANDS FOR RECREATIONAL SNOWMOBILE USE (GUIDELINES FOR NATURAL RESOURCES MANAGEMENT AND LAND USE COMPATIBILITY). Construction Engineering Research Lab.(Army). Champaign, Ill. 1981.
Note: new.

98. Lee, M. E., D. R. Field, and K. Schwarzkopf. PEOPLE, HUMAN BEHAVIOR AND ANIMALS IN PARKS AND PRESERVES: A WORKING BIBLIOGRAPHY. Natl. Park Serv., Coop. Park Stud. Unit Publ. CPSU/OSU 84-11. Coll. For., Oregon State Univ., Corvallis. 35 pp. 1984.
Note: new.

99. Lieb, J. W. ACTIVITY, HEART RATE, AND ASSOCIATED ENERGY EXPENDITURE IN ELK OF WESTERN MONTANA. Ph.D. Thesis, Univ. of Montana, Missoula. 200 pp. 1981.
Note: new.

100. Lindberg, K. and D. E. Hawkins, eds. ECOTOURISM: A GUIDE FOR PLANNERS AND MANAGERS. The Ecotourism Society. North Bennington, Vermont. 1993.
Note: new.

101. Lindenmayer, D. B. and H. A. Nix. ECOLOGICAL PRINCIPLES FOR THE DESIGN OF WILDLIFE CORRIDORS. Conservation Biology 7:627-630. 1973.
Note: new.

102. Lodico, N. J. ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES: A REVIEW OF THE LITERATURE. USDI Office of the Secretary, Washington, D.C. 1973.
Note: new.

103. Lyon, L. J. ROAD DENSITY MODELS DESCRIBING HABITAT EFFECTIVENESS FOR ELK. Journal of Forestry, September:592-595. 1983.
Note: new.
Forest roads evoke an avoidance response by elk.

104. MacAarthur, R. H. and E. O. Wilson. THEORY OF ISLAND BIOGEOGRAPHY. Princeton University Press. Princeton, N.J. 1967.
Note: new.

105. MacNab, J. WILDLIFE MANAGEMENT AS SCIENTIFIC EXPERIMENTATION. Wildl. Soc. Bull. 11:397-401. 1983.
Note: new.

106. Maldague, M. IMPACT OF SNOWMOBILES ON THE FOREST ENVIRONMENT. Forest Conservation 39(9):6-8. 1973.
Note: new.

107. Manfredo, M. J., J. J. Vaske, and D. J. Decker. HUMAN DIMENSIONS OF WILDLIFE MANAGEMENT: BASIC CONCEPTS. In: Wildlife and Recreationists: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 17-31. Island Press. Washington, D.C. 1995.
Note: new.

108. Manning, R. E. IMPACTS OF RECREATION ON RIPARIAN SOILS AND VEGETATION. Water Resources Bulletin 50:30-43. 1979.
Note: new.

109. Manuwal, D. A. EFFECT OF MAN ON MARINE BIRDS: A REVIEW. In: Proc. Wildlife and People, C. M. Kirkpatrick, ed., pp. 140-160. Purdue Res. Foundation. West Lafayette, Ind. 1978.
Note: new.

110. Marshall, O. PRELIMINARY STUDIES ON THE EFFECTS OF SNOWMOBILE COMPACTION ON SOME TERRESTRIAL INVERTEBRATES. Amer. Zool. 1972.
Note: new.

111. Masyk, W. J. SNOWMOBILE, A RECREATION TECHNOLOGY IN BANFF NATIONAL PARK; ENVIRONMENTAL IMPACT AND DECISION-MAKING. Univ. of Calgary; The Univ. of Western Ontario, London, Ontario. 1973.
Note: new.

112. Mayes, A. THE PHYSIOLOGY OF FEAR AND ANXIETY. In: Fear in Animals and Man, W. Sluckin, ed., pp. 24-55. Van Nostrand Reinhold Company, New York, N.Y. 1979.
Note: new.
Physiological and behavioral responses to disturbance.

113. McCool, S. F. SNOWMOBILES, ANIMALS, AND MAN: INTERACTIONS AND MANAGEMENT ISSUES. Trans. North Amer. Wildl. and Nat. Resour. Conf. 43:140-148. 1978.
Note: new.

114. McCool, S. F. SNOWMOBILES, ANIMALS, AND MAN: INTERACTIONS AND MANAGEMENT ISSUES. The Wildlife Management Institute. Washington, D.C. 23 pp. 1978.
Note: new.

115. McCool, S. F. and B. Curtis. SOURCES OF CONFLICT AMONG WINTER RECREATIONISTS. In: Proc. North American Symposium on Dispersed Winter Recreation, pp. 73-77. Univ. of Minn. Office of Spec. Prog., Educ. Ser. 2-3. 1980.
Note: new.

116. Meagher, M. S. Cain, T. Toman, J. Kropp, and D. Bosman. BISON IN THE GREATER YELLOWSTONE AREA: STATUS, DISTRIBUTION AND MANAGEMENT. Paper presented at the National Brucellosis Symposium, Jackson Hole, Wyo., September. 1994.
Note: new.

117. Meagher, M. THE BISON OF YELLOWSTONE NATIONAL PARK: PAST AND PRESENT. Ph.D. Dissertation, Univ. of Calif., Berkeley. 172 pp. 1970.
Note: new.

118. Meagher, M. RANGE EXPANSION BY BISON OF YELLOWSTONE NATIONAL PARK. Journal of Mammal. 70:670-675. 1989.
Note: new.
Bison use of plowed roads, an increase in numbers, acquired knowledge of new foraging areas, and the natural gregariousness of bison contributed to range expansion.

119. Meagher, M. WINTER WEATHER AS A POPULATION REGULATING INFLUENCE ON FREE-RANGING BISON IN YELLOWSTONE NATIONAL PARK. In: Research in Parks, Transactions of the National Park Centennial Symposium of the American Association for the Advancement of Science, Dec. 28-29, 1971. Ser. No. 1. Washington, D.C.: U.S. Government Printing Office. 232 pp. 1976.
Note: new.

120. Meagher, M. WINTER RECREATION-INDUCED CHANGES IN BISON NUMBERS AND DISTRIBUTION IN YELLOWSTONE NATIONAL PARK. Draft, report to management, unpublished. 48 pp. 1993. Research Library, vertical files, Yellowstone Park, Wyoming.
Note: new.
Snow-packed roads used for winter recreation in the interior of the park appeared to be the major influence in major changes that occurred in bison numbers and distribution in Yellowstone, during the past decade. The entire bison population is involved, effects will ultimately occur on the ecosystem level. Range expansion, major shifts among subpopulations, mitigation of winterkill, and enhanced calf survival have resulted.

121. Meagher, M. WINTER RECREATION-INDUCED CHANGES IN BISON NUMBERS AND DISTRIBUTION IN YELLOWSTONE NATIONAL PARK. Unpublished. 1993.
Note: new.

122. Mietz, J. D. SNOWMOBILE IMPACT ON FOREST VEGETATION AT HEIBERG FOREST, NEW YORK. State University of New York, College of Environmental Science and Forestry, Syracuse, N.Y. 1974.
Note: new.

123. Miller, S. G. and R. L. Knight. IMPACTS OF RECREATIONAL TRAILS ON AVIAN COMMUNITIES. In: Abstracts from the Society of Conservation Biology Meeting. Dept. of Fishery and Wildlife Biology, Colorado State University, Fort Collins, Colo. 1995.
Note: new.

124. Moen, A. N., S. Whittemore, and B. Buxton. EFFECTS OF DISTURBANCE BY SNOWMOBILES ON HEART RATE OF CAPTIVE WHITE-TAILED DEER (*Odocoileus virginianus*). New York Fish and Game Journal 29(2):176-183. 1982.
Note: new.

125. Montana Department of Fish, Wildlife and Parks. PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT. Montana Snowmobile Grant Program. Prepared by Statewide Trails Program Coordinator, Montana Dept. of Fish, Wildlife and Parks, 1420 E. Sixth Ave., Helena, Mont. 59620. 1993.
Note: new.
126. Montopoli, G. L. and D. A. Anderson. LOGISTICAL MODEL FOR THE CUMULATIVE EFFECTS OF HUMAN INTERVENTION ON BALD EAGLE HABITAT. Jour. Wildl. Manage. 55:290-293. 1991.
Note: new.
127. Morrison, J. R. EFFECTS OF SKI AREA EXPANSION ON ELK AND ACCURACY OF TWO TELEMETRY SYSTEMS IN MOUNTAINOUS TERRAIN. M. S. Thesis, Colorado State University, Fort Collins, Colo. 98 pp. 1992.
Note: new.
128. Noss, R. F. and A. Y. Cooperrider. SAVING NATURE'S LEGACY: PROTECTING AND RESTORING BIODIVERSITY. Island Press. Washington, D.C. 1994.
Note: new.
129. Odum, E. P. TRENDS EXPECTED IN STRESSED ECOSYSTEMS. BioScience 35:419-422. 1985.
Note: new.
130. Pederson, R. J. MANAGEMENT AND IMPACTS OF ROADS IN RELATION TO ELK POPULATIONS. In: Conf. Proc. Recreational Impact on Wildlands, R. Ittner, D. R. potter, J. K. Agee, and S. Anschell, eds., pp. 169-173. U.S. Forest Serv., U.S. Natl. Park Serv. R-6-001-1979. 1979.
Note: new.
Construction of roads in elk habitat effectively eliminated prime areas from elk production.
131. Pedevillano, C. and R. G. Wright. INFLUENCE OF VISITORS ON MOUNTAIN GOAT ACTIVITIES IN GLACIER NATIONAL PARK. Biological Conservation 39:1-11. 1987.
Note: new.
Goats at mineral licks apparently not disturbed by visitors, but goats attempting to cross goat underpasses were negatively affected by numbers of vehicles on the highway.
132. Peek, J. and D. B. Siniff. WILDLIFE-SNOWMOBILE INTERACTIONN PROJECT: PROGRESS REPORT. Univ. Minnesota Dept. Entom., Fish, Wildl., Ecol. and Behav. Biol., and Minn. Dept. of Natural Resources, St. Paul, Minn. 1972.
Note: new.
133. Perry, C. and R. Overly. IMPACT OF ROADS ON BIG GAME DISTRIBUTION IN PORTIONS OF THE BLUE MOUNTAINS OF WASHINGTON, 1972-1973. Washington Game Department. 1976.
Note: new.
General reduction of use up to 1/8 mile from roads, depending on amount of roadside cover; deer substantially affected in meadows when cover was lacking.

134. Pruitt, W. O. SNOWMOBILES AND ALL-TERRAIN VEHICLES. Paper presented at Conference on Snowmobiles and All-Terrain Vehicles. Univ. of Western Ontario, Dept. Zool. Res. Report, University of Manitoba, Winnipeg, Canada. 1971.
Note: new.
Discussed impacts of snowmobiles on the subnivean environment.
135. Purdy, K. G., G. R. Goff, D. J. Decker, G. A. Pomerantz, and N. A. Connelly. GUIDE TO MANAGING HUMAN ACTIVITY ON NATIONAL WILDLIFE REFUGES. USDI Fish and Wildlife Service, Office of Information Transfer. Fort Collins, Colorado. 1987.
Note: new.
136. Rapport, D. J., H. A. Regier, and T. C. Hutchinson. ECOSYSTEM BEHAVIOR UNDER STRESS. American Naturalist 125:617-640. 1985.
Note: new.
137. Regelin, W. L., C. C. Schwartz, and A. W. Franzmann. SEASONAL ENERGY METABOLISM IN MOOSE. J. Wildl. Manage. 49:388-393. 1985.
Note: new.
138. Renecker, L. A. and R. J. Hudson. SEASONAL ENERGY EXPENDITURES AND THERMOREGULATORY RESPONSES OF MOOSE. Can. Jour. Zoology 64:322-327. 1986.
Note: new.
139. Roggenbuck, J. W. USE OF PERSUASION TO REDUCE RESOURCE IMPACTS AND VISITOR CONFLICTS. In: Influencing Human Behavior, M. J. Manfredo, ed., pp. 149-208. Sagamore Publishing, Inc. Champaign, Ill. 1992.
Note: new.
140. Rongstad, O. J. RESEARCH NEEDS ON ENVIRONMENTAL IMPACTS OF SNOWMOBILES. In: Off-road Vehicle Use: A Management Challenge, N. Andrews, L. Richard, and P. Nowak, eds., USDA Ofc. of Environmental Quality. Washington, D.C. 1980.
Note: new.
141. Rosenmann, M. and P. Morrison. PHYSIOLOGICAL CHARACTERISTICS OF THE ALARM REACTION IN THE DEER MOUSE. Physiological Zoologica 47:230-241. 1974.
Note: new.
142. Rost, G. A. and J. A. Bailey. DISTRIBUTION OF MULE DEER AND ELK IN RELATION TO ROADS. J. Wildl. Manage. 43:634-641. 1979.
Note: new.
143. Ruggiero, L. F., G. D. Hayward, and J. R. Squires. VIABILITY ANALYSIS IN BIOLOGICAL EVALUATIONS: CONCEPTS OF POPULATION VIABILITY ANALYSIS, BIOLOGICAL POPULATION, AND ECOLOGICAL SCALE. Conservation Biology 8(2):364-372. 1994.
Note: new.
Reviewed population viability analysis (PVA). Suggested that assessments must address population persistence and habitat dynamics. A 7-step guide for PVA was provided.
144. Russell, D. OCCURRENCE AND HUMAN DISTURBANCE SENSITIVITY OF WINTERING BALD EAGLES ON THE SAUK AND SUIATTLE RIVERS, WASHINGTON. In: Proceedings of Washington Bald Eagle Symposium, R. L. Knight, G. T. Allen, M. V. Stalmaster, and C. W. Servheen, eds., pp. 165-174. 1980.
Note: new.

145. Sachet, G. A. INTEGRATED TRAIL PLANNING GUIDELINES FOR WILDLIFE, RECREATION AND FISH RESOURCES ON MT. HOOD NATIONAL FOREST. USDA Forest Service. 1990.
Note: new.
146. Salwasser, H. and F. Samson. CUMULATIVE EFFECTS ANALYSIS: AN ADVANCE IN FOREST PLANNING AND WILDLIFE MANAGEMENT. Tran. No. Amer. Wildl. and Nat. Res. Conf. 50:313-321. 1985.
Note: new.
147. Salwasser, H. C. Schoenwald-Cox, and R. Baker. ROLE OF INTERAGENCY COOPERATION IN MANAGING FOR VIABLE POPULATIONS. In: Viable Populations for Conservation, M. E. Soule, ed., pp. 159-173. Cambridge University Press. 1972.
Note: new.
148. Samuel, M. D. and R. E. Green. A REVISED TEST PROCEDURE FOR IDENTIFYING CORE AREAS WITHIN THE HOME RANGE. J. An. Ecology 57:1067-1068. 1988.
Note: new.
Revised his 1985 paper in same journal.
149. Schleyer, B. O. ACTIVITY PATTERNS OF GRIZZLY BEARS IN THE YELLOWSTONE ECOSYSTEM AND THEIR REPRODUCTIVE BEHAVIOR, PREDATION, AND USE OF CARRION. M. S. Thesis, Montana State Univ., Bozeman, Mont. 1983.
Note: new.
150. Schmid, W. D. MODIFICATION OF THE SUBNIVEAN MICROCLIMATE BY SNOWMOBILES. In: Snow and Ice in Relation to Wildlife and Recreation, Symposium Proceedings, pp. 251-257. Coop. Wildl. Res. Unit, Iowa State Univ., Ames, IA. 1971.
Note: new.
151. Schultz, R. D. RESPONSES OF NATIONAL PARK ELK TO HUMAN ACTIVITY. M.S. thesis. Univ. of Montana. 95 pp. 1975.
Note: new.
152. Scom, A. J. G. Bollinger, and O. J. Rongstad. STUDYING THE EFFECTS OF SNOWMOBILE NOISE ON WILDLIFE. Internoise Proceedings 236-241. 1972.
Note: new.
153. Shaffer, M. L. MINIMUM VIABLE POPULATIONS COPING WITH UNCERTAINTY. In: Viable Populations for Conservation, M. E. Soule, ed., pp. 69-86. Cambridge University Press, Cambridge. 1987.
Note: new.
154. Shaffer, M. L. POPULATION VIABILITY ANALYSIS. Conservation Biology 4(1):39-40. 1990.
Note: new.
155. Shaffer, M. L. POPULATION VIABILITY ANALYSIS. In: Challenges in Conservation of Biological Resources: A Practioner's Guide, D. Decker et al., eds., pp. 107-119. Westview Press. San Francisco, Calif. 1992.
Note: new.
156. Shea, R. E. ECOLOGY OF THE TRUMPETER SWAN IN YELLOWSTONE NATIONAL PARK AND VICINITY. M. S. thesis. Univ. of Montana. 132 pp. 1979.
Note: new.

157. Shoesmith, M. W. SEASONAL MOVEMENTS AND SOCIAL BEHAVIOR OF ELK ON MIRROR PLATEAU, YELLOWSTONE NATIONAL PARK. In: North American Elk: Ecology, Behavior and Management, M. S. Boyce and L. D. Hayden-Wing, eds., pp. 166-176. Univ. of Wyoming, Laramie, Wyo. 1980.
Note: new.

158. Simberloff, D. and J. Cox. CONSEQUENCES AND COSTS OF CONSERVATION CORRIDORS. Conserv. Biol. 1:63-71. 1987.
Note: new.

159. Simberloff, D. and L. G. Abele. REFUGE DESIGN AND ISLAND BIOGEOGRAPHIC THEORY: EFFECTS OF FRAGMENTATION. Am. Nat. 120:41-50. 1987.
Note: new.

160. Singer, F. J. and J. B. Beattie. CONTROLLED TRAFFIC SYSTEM AND ASSOCIATED RESPONSES IN DENALI NATIONAL PARK. Arctic 39:195-203. 1986.
Note: new.
Moose were more alert to vehicle traffic than were caribou.

161. Skagen, S. K. BEHAVIORAL RESPONSES OF WINTERING BALD EAGLES TO HUMAN ACTIVITY ON THE SKAGIT RIVER, WASHINGTON. In: Proceedings of the Washington Bald Eagle Symposium, R. L. Knight et al., eds. The Nature Conservancy. 1980.
Note: new.

162. Smith, A. T. and M. M. Peacock. CONSPECIFIC ATTRACTION AND THE DETERMINATION OF METAPOPULATION COLONIZATION RATES. Conservation Biology 4:320-323. 1990.
Note: new.
Recolonization of habitats after disturbance.

163. Soule, M. E. and D. Simberloff. WHAT DO GENETICS AND ECOLOGY TELL US ABOUT THE DESIGN OF NATURE RESERVES? Biol. Conservation 35:19-40. 1986.
Note: new.

164. Stace-Smith, R. MISUSE OF SNOWMOBILES AGAINST WILDLIFE IN CANADA. Nat. Can. 494:3-8. Ottawa. 1975.
Note: new.

165. Stalmaster, M. V. and J. A. Gessaman. ECOLOGICAL ENERGETICS AND FORAGING BEHAVIOR OF OVERWINTERING BALD EAGLES. Ecological Monographs 54:407-428. 1984.
Note: new.
High levels of human disturbance during winter could increase energy demands and result in increased mortality rates.

166. Stalmaster, M. V., J. K. Kaiser, and S. K. Skagen. EFFECTS OF RECREATIONAL ACTIVITY ON FEEDING BEHAVIOR OF WINTERING BALD EAGLES. J. Raptor Research 27(1):93. 1983.
Note: new.

167. Stankey, G. H., D. N. Cole, R. C. Lucas, M. E. Peterson, and S. S. Frissell. LIMITS OF ACCEPTABLE CHANGE (LAC) SYSTEM FOR WILDERNESS PLANNING. General Technical Report INT-176. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah. 19815.
Note: new.
Follows carrying capacity concepts (no set number of visitors). Sets quantifiable standards of impact levels that trigger management actions.

168. Stemp, R. E. HEART RATE RESPONSES OF BIGHORN SHEEP TO ENVIRONMENTAL FACTORS AND HARASSMENT. M. S. Thesis, Univ. of Calgary, Alberta, Canada. 371 pp. 1983.
Note: new.

169. Stockwell, C. A., G. C. Bateman, and J. Berger. CONFLICTS IN NATIONAL PARKS: A CASE STUDY OF HELICOPTERS AND BIGHORN SHEEP TIME BUDGETS AT GRAND CANYON. Biological Conservation 56:317-328.
Note: new.
Frequent alerting affected food intake.

170. Sweeney, J. M. and J. R. Sweeney. SNOW DEPTHS INFLUENCING WINTER MOVEMENTS OF ELK. Jour. of Mammalogy 65(3):524-526. 1984.
Note: new.

171. Taylor, C. R., N. C. Heglund, and G. M. Maloiy. ENERGETICS AND MECHANICS OF TERRESTRIAL LOCOMOTION. Jour. Exp. Biol. 97:1-21. 1982.
Note: new.

172. Telfer, E. S. and J. P. Kelsall. STUDIES OF MORPHOLOGICAL PARAMETERS AFFECTING UNGULATE LOCOMOTION IN SNOW. Can. Jour. Zool. 57:2153-2159. 1982.
Note: new.

173. Tennessee State University, Memphis. EFFECTS OF NOISE ON WILDLIFE AND OTHER ANIMALS. U.S. Govt. Printing Ofc., Washington, D.C. 74 pp. 1971.
Note: new.
Prepared for U.S. Ofc. of Noise Abatement and Control.

174. Tenpas, G. H. EFFECTS OF SNOWMOBILE TRAFFIC ON NON-FOREST VEGETATION. Lake Superior Biological Conference, Ashland, Wisc. 1972.
Note: new.

175. Thomas, J. W., ed. WILDLIFE HABITATS IN MANAGED FORESTS IN THE BLUE MOUNTAINS OF OREGON AND WASHINGTON. USDA Forest Service Handbook 553. 512 pp. 1979.
Note: new.
A most comprehensive study of deer and elk management. Provides tools for identifying cover and vegetation types. Quantifies impacts from management activities, including roads.

176. Thorne, E. T., R. E. Dean, and W. G. Hepworth. NUTRITION DURING GESTATION IN RELATION TO SUCCESSFUL REPRODUCTION IN ELK. J. Wildl. Manage. 40:330-335. 1976.
Note: new.

177. University of Wisconsin, Madison. EFFECTS OF SNOWMOBILE TRAFFIC ON NON-FOREST VEGETATION: SECOND REPORT. College of Agricultural and Life Sciences, Dept. of Agronomy, Univ. of Wisconsin, Madison. 1973.
Note: new.

178. USDI, U.S. National Park Service. PUBLIC USE AND RECREATION; VEHICLES AND TRAFFIC SAFETY. Federal Register 38. Feb. 14, 1973:4405-4407. 1973.
Note: new.

179. USDI, U.S. National Park Service. WINTER USE PLAN ENVIRONMENTAL ASSESSMENT, YELLOWSTONE AND GRAND TETON NATIONAL PARKS AND JOHN D. ROCKEFELLER, JR., MEMORIAL PARKWAY, WYOMING, IDAHO, AND MONTANA. 114 pp. 1990.
Note: new.

180. VanDyke, F. G., R. H. Brocke, H. G. Shaw, B. B. Ackerman, T. P. Hemker, and F. G. Lindzey. REACTIONS OF MOUNTAIN LIONS TO LOGGING AND HUMAN ACTIVITY. J. Wildl. Manage. 50:95-102. 1986.
Note: new.

181. Vaske, J. J., D. J. Decker, and M. J. Manfredo. HUMAN DIMENSIONS AND WILDLIFE MANAGEMENT: AN INTEGRATED FRAMEWORK FOR COEXISTENCE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 33-49. Island Press. Washington, D.C. 1995.
Note: new.

182. Vaske, J. J., A. R. Graefe, and F. R. Kuss. RECREATION IMPACTS: A SYNTHESIS OF ECOLOGICAL AND SOCIAL RESEARCH. Trans. North Amer. Wildl. and Nat. Resour. Conf. 48:96-107. 1983.
Note: new.

183. Wallace, G. N. VISITOR MANAGEMENT: LESSONS FROM GALAPAGOS NATIONAL PARK. In: Ecotourism: A Guide for Planners and Managers, K. Lindberg and D. E. Hawkins, eds., pp.55-81. The Ecotourism Society. North Bennington, Vermont. 1993.
Note: new.

184. Walter, H. and K. L. Garrett. EFFECTS OF HUMAN ACTIVITY ON WINTERING BALD EAGLES IN THE BIG BEAR VALLEY, CALIFORNIA. FINAL REPORT. USDA Forest Service, Big Bear District, Fawnskin, Calif. 79 pp. 1981.
Note: new.
Snow machines and ATVs are especially disturbing, probably due to association with random movement, loud noise, and operators are generally exposed.

185. Wanek, W. J. and L. H. Schumacher. A CONTINUING STUDY OF THE ECOLOGICAL IMPACT OF SNOWMOBILING IN NORTHERN MINNESOTA. FINAL REPORT FOR 1974-1975. State College, Bemidji, Minn. 1975.
Note: new.

186. Wanek, W. J. ECOLOGICAL IMPACT ON VEGETATION AND SOIL MICROBES. In: Snowmobile and Off the Road Vehicle Research Symposium Proceedings. Recreation Resour., Michigan State Univ. 1973.
Note: new.

187. Wanek, W. J. SNOWMOBILING IMPACT ON VEGETATOIN, TEMPERATURES AND SOIL MICROBES. In: Snowmobile and Off the Road Vehicle Research Symposium Proceedings, pp. 117-130. 1971.
Note: new.

188. Ward, A. L. EFFECTS OF HIGHWAY CONSTRUCTION AND USE ON BIG GAME POPULATIONS. Fed. Highway Ofc. Res. and Dev. Rep. FHWA-RD-76-174. Nat. Tech. Inf. Serv., Springfield, Va. 92 pp. 1976.
Note: new.

189. Ward, A. L. TELEMETERED HEART RATE OF THREE ELK AS AFFECTED BY ACTIVITY AND HUMAN DISTURBANCES. In: Proceedings of Symposium: Dispersed Recreation and Natural Resource Management. Utah State Univ. 1977.
Note: new.
Two cow elk and a spike. Positive correlation to man-caused disturbance and elevated heart rates. Highest incidence occurred with loud noises and direct interaction.

190. Ward, A. L. and J. J. Cupal. TELEMETERED HEART RATE OF THREE ELK AS AFFECTED BY ACTIVITY AND HUMAN DISTURBANCE. Rocky Mt. Forest and Range Exper. Sta., Laramie, Wyo. 1980.
Note: new.

191. Warren, H. V. and R. E. Delavault, cited in H. L. Cannon and J. M. Bowles. CONTAMINATION OF VEGETATION BY TETRAETHYL LEAD. Science 137:765-766.
Note: new.

192. Watson, A. BIRD AND MAMMAL NUMBERS IN RELATION TO HUMAN IMPACT AT SKI LIFTS ON SCOTTISH HILLS. Jour. of Applied Ecology 16:753-754. 1979.
Note: new.

193. Whelan, T. ed. NATURE TOURISM: MANAGING FOR THE ENVIRONMENT. Island Press. Washington, D.C. 1991.
Note: new.

194. White, P. S. and S. P. Bratton. AFTER PRESERVATION; PHILOSOPHICAL AND PRACTICAL PROBLEMS OF CHANGE. Biol. Conservation 18:241-255. 1980.
Note: new.
It is not only the recreationist who impacts wildlands, but the scientist, educator, and school group as well.

195. Whittaker, J. SNOWMOBILING OVER FORAGE GRASSES. Paper presented at Conference on Snowmobiles and All-terrain Vehicles at Univ. of Western Ontario, Canada. 1971.
Note: new.

196. Wiens, J. A. SPATIAL SCALING IN ECOLOGY. Functional Ecology 3:385-397. 1989.
Note: new.

197. Wilcox, B. A. and D. D. Murphy. CONSERVATION STRATEGY: THE EFFECTS OF FRAGMENTATION ON EXTINCTION. Am. Nat. 125:879-887.
Note: new.

198. Williams, M. and A. Lester. ANNOTATED BIBLIOGRAPHY OF OHV AND OTHER RECREATIONAL IMPACTS TO WILDLIFE. Eldorado National Forest. USDA Forest Service, Pacific Southwest Region. 10 pp. 1996.
Note: new.

199. Witmer, G. W. and D. S. deCalesta. EFFECT OF FOREST ROADS ON HABITAT USED BY ROOSEVELT ELK. Northwest Science 59(2):122-124. 1985.
Note: new.
Six females monitored for one year. Human activity on forest roads alters distributions of elk habitat use. Impact may be mitigated by road closures, especially during rutting and calving seasons.

200. Young, J. and A. Boyce. RECREATIONAL USES OF SNOW AND ICE IN MICHIGAN AND SOME OF ITS EFFECTS ON WILDLIFE AND PEOPLE. In: Proceedings of the Snow and Ice Symposium. Iowa Coop. Wildl. Res. Unit, Iowa State Univ., Ames. 820 pp. 1971.
Note: new.
Includes skiing.

ADDENDUM

Anonymous. 1992. News and notes. Yellowstone Science, Yellowstone National Park, Wyo. 21 pp.

——— 1996a. Yellowstone Center for Resources 1995 Annual Report, S. Consolo Murphy, M.A. Franke and S. Broadbent, eds., Yellowstone Park, Wyo. 82 pp.

——— 1996b. Investigators' Annual Reports for 1995, B. Lindstrom and S. Broadbent, eds., Yellowstone Park, Wyo. 134 pp.

Barnes, V.G. Jr. and O.E. Bray. 1967. Final report: Population characteristics and activities of black bears in Yellowstone National Park. Colo. Coop. Wildl. Research Unit, Colo. State Univ., Fort Collins. 199 pp.

Beall, R.C. 1974. Winter habitat selection and use by a western Montana elk herd. Ph.D. Thesis. Univ. of Montana, Missoula. 197 pp.

Cole, G.F. 1972. Grizzly bear-elk relationships in Yellowstone National Park. J. Wildl. Manage. 36(2):556-570.

DelGuidice, G., F.J. Singer, U.S. Seal and G. Bowser. 1994. Physiological responses of Yellowstone bison to winter nutritional deprivation. J. Wildl. Manage. 58(1):24-34.

Goodrich, J.M. and J. Berger. 1994. Winter recreation and hibernating black bears <u>Ursus americanus</u>. Biological Conservation 67:105-110.

Green, G.I. 1988. Dynamics of ungulate carcass availability and use by bears on the northern range and Firehole and Gibbon drainages. Yellowstone Grizzly Bear Investigations: Annual Report of the Interagency Bear Study Team, R.R. Knight, B.M. Blanchard and M. Mattson, eds., U.S. National Park Service, Bozeman, Mont.

Mattson, D. J. and J. Henry. 1987. Spring grizzly bear use of ungulate carcasses in the Firehole River drainage: Second Year Progress Report. Pp. 63-72 in Yellowstone Grizzly Bear Investigations: Annual Report of the Interagency Study Team 1986. USDI National Park Service. Bozeman, Mont.

Thurber, J.M., R.O. Peterson, T.D. Drummer, and S.A. Thomasa. 1994. Gray wolf response to refuge boundaries and roads in Alaska. Wildl. Soc. Bull. 22(1):61-68.

Wesley, D.E., K.L. Knox and J.G. Nagy. 1973. Energy metabolism of pronghorn antelope. J. Wildl. Manage. 57:563-573.

Appendix II

SELECTED LITERATURE CITATIONS FROM BENNETT 1995[1] AND NEW CITATIONS FROM CASLICK 1997[2] ON WINTER RECREATION EFFECTS ON WILDLIFE

J. and E. Caslick
Resource Management, YCR
Yellowstone Park, WY 82190

March 1997

[1]Bennett, L.E. 1995. A review of potential effects of winter recreation on wildlife in Grand Teton and Yellowstone National Parks: a bibliographic data base. Univ. of Wyo. Coop. Fish and Wildlife Research Unit, Laramie. 108 pp.

[2]Caslick, J. and E. 1997. New citations on winter recreation effects on wildlife. Resource Management, YCR, Yellowstone Park, Wyo. 22 pp.

1. Aasheim, R. SNOWMOBILE IMPACTS ON THE NATURAL ENVIRONMENT. in: R. N. L. Andrews; and P. F. Nowak, eds. Off-road Vehicle use: A Management Challenge; Conf. Proc., 16-18 March 1980. Ann Arbor, MI. 1980.
Snowmobiling and its impacts on natural environments in Montana are described. Studies of impacts on deer and elk have produced conflicting results, but there is little doubt that additional stress in winter is undesirable. Animals accustomed to humans are less affected by snowmobiles than animals in more remote areas. Effects on small mammals and possible effects of packed snowmobile trails are discussed.
2. Adams, E. S. EFFECTS OF LEAD AND HYDROCARBONS FROM SNOWMOBILE EXHAUST ON BROOK TROUT (*Salvalinus fontinalis*). Trans. Amer. Fish Soc.; 104(2):363-373. 1975.
Field and lab study on fingerling brook trout.
3. Allbrecht, J.; and D. Smith. ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES: A SELECTED BIBLIOGRAPHY OF PUBLICATIONS IN THE UNIVERSITY OF MINNESOTA FORESTRY LIBRARY. Univ. Minnesota, St. Paul Campus Libraries, For. Serv. Libr. Bibligr. Ser. 2. 9 pp. 1977.
*Bibliography.
4. Alldredge, R. B. SOME CAPACITY THEORY FOR PARKS AND RECREATION AREAS. National Park Service Reprint. 1972.
5. Allen, J. N. *THE ECOLOGY AND BEHAVIOR OF THE LONG-BILLED CURLEW IN SOUTHEASTERN WASHINGTON. Wildl. Monogr. 73:1-67. 1980.
6. Allen, R. P. *THE WHOOPING CRANE. National Audubon Society, Rep. 3, New York. 246 pp. 1952.
7. Allendorf, F. W.; and C. Serveen. *GENETICS AND THE CONSERVATION OF GRIZZLY BEARS. Trends in Ecol. and Evol.; 1:88-89. 1986.
8. Alt, K. L. ECOLOGY OF THE BREEDING BALD EAGLE AND OSPREY IN THE GRAND TETON-YELLOWSTONE NATIONAL PARKS COMPLEX. M. S. thesis. Univ. of Montana. 95 pp. 1980.
Note: new.
9. Altman, M. THE FLIGHT DISTANCE IN FREE-RANGING BIG GAME. J. Wildl. Manage.; 22(2):207-209. 1958.
The distance at which free-ranging elk and moose would flee from humans varied with habitat, social groupings, nutrition, reproductive status, and specific experience of individual animals of the group (Ream 1980).
10. Anderson, D. L. A WINDOW TO THE NATURAL WORLD: THE DESIGN OF ECOTOURISM FACILITIES. In Ecotourism: A Guide for Planners and Managers, eds. K. Lindberg and D. E. Hawkins, 116-153. North Bennington, Vermont: The Ecotourism Society. 1993.
Note: new.
Emphasis on design to reduce environmental impacts and enhance visitors' satisfaction and awareness of the environment.

11. Anderson, D. W.; and J. O. Kieth. THE HUMAN INFLUENCE ON SEABIRD NESTING SUCCESS: CONSERVATION IMPLICATIONS. Biol. Conserv.; 18:65-80. 1980. Studies of brown pelicans and Heerman's gulls indicated that disturbances by recreationists, educational groups, and scientists could seriously disrupt seabird breeding on the coast of Baja California. Human disturbances lead to inter- and intra-specific behavioral imbalances in seabirds. Methods for minimizing disturbances are discussed (Boyle and Sampson 1983).
12. Anderson, E. M. *A CRITICAL REVIEW AND ANNOTATED BIBLIOGRAPHY OF LITERATURE ON THE BOBCAT. Colorado Division of Wildlife, Special Report No. 62. 61 pp. 1987.
13. Anderson, S. H. *COMPARATIVE FOOD HABITS IN OREGON NUTHATCHES. Northwest Sci.; 50:213-221. 1976.
14. Anderson, S. H. RECREATIONAL DISTURBANCE AND WILDLIFE POPULATIONS. In R. L. Knight and K. J. Gutzwiller, eds. Wildlife and Recreation: Coexistence Through Management and Research. Island Press. Washington, D.C. 1995.
Note: new.
15. Anthony, A. and E. Ackerman. EFFECTS OF NOISE ON THE BLOOD EOSINOPHIL LEVELS AND ADRENALS OF MICE. Journal of the Acoustical Society of America 27(6):1144-1149. 1955.
Note: new.
16. Anthony, R. G., R. J. Steidl, and K. McGarigal. RECREATION AND BALD EAGLES IN THE PACIFIC NORTHWEST. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 223-241. Island Press, Washington, D.C. 1995.
Note: new.
Human disturbance is most serious for eagles that depend on large fish or mammal carcasses as their major food source.
17. Armstrong, F. H. *NOTES ON SOREX PREBLEI IN WASHINGTON STATE. Murrelet; 38:6. 1957.
18. Aune, K. E. IMPACT OF WINTER RECREATIONISTS ON WILDLIFE IN A PORTION OF YELLOWSTONE NATIONAL PARK, WYOMING. M.S. thesis; Montana State Univ., Bozeman. 111 pp. 1981.
General responses of wildlife to winter recreationists in Yellowstone National Park were attention or alarm, light, and, rarely, aggression. Responses varied with the species involved, nature of the disturbance, and time of season. Winter recreation activities was not a major factor influencing wildlife distributions, movements, or population sizes, although minor displacement of wildlife from areas adjacent to trails was observed. Management recommendations are presented (Boyle and Sampson 1983).

19. Austin, J. E. WINTER ECOLOGY OF CANADA GEESE IN NORTHCENTRAL MISSOURI. Ph.D., University of Missouri, Columbia. 284 pp. 1988.
Canada geese tended to spend more of their time in agricultural habitats where they were more vulnerable to disturbances than in seasonal wetlands in the refuge interior or the water roost sites. Vigilance of waterfowl did not differ by habitat in the hunting season, thus the effects of disturbances by hunters are far-reaching. All use of wetlands in late fall occurred in the refuge interior, which is not hunted. However, in response to gunshots from the hunting zone, geese in the refuge interior often ceased other activities and, at least briefly, became alert or vigilant. Habituation of Canada geese to disturbances in some locations may account for the lower vigilance of geese in pastures in winter. These pastures seemed to be traditionally used by geese and may be considered safe fields. Geese seemed to avoid or leave locations where excessive disturbances restricted feeding and where they did not habituate to disturbances.

20. Bailey, T. N. *FACTORS OF BOBCAT SOCIAL ORGANIZATION AND SOME MANAGEMENT IMPLICATIONS. Pages 984-1000 in: J. A. Chapman and D. Pursley, eds. Proc. Worldwide Furbearer Conf., Frostburg, MD. 1981.

21. Baldwin M. F., and D. H. Stoddard. THE OFF-ROAD VEHICLE AND ENVIRONMENTAL QUALITY. Second edition, the Conservation Foundation; Washington, D.C. 61 pp. plus foldout chart. 1973.
This report updates an earlier edition describing the effects of off-road vehicles, particularly snowmobiles. A section on fish and wildlife reviews literature describing harassment of wildlife, and legal responses to adverse impacts of off-road vehicles on wildlife. Policies for control of environmental impacts are suggested (Boyle and Sampson 1983).

22. Baldwin, F. M. THE OFF-ROAD VEHICLE AND ENVIRONMENTAL QUALITY; A REPORT ON THE SOCIAL AND ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES, PARTICULARLY SNOWMOBILES, WITH SUGGESTED POLICIES FOR THEIR CONTROL. The Conservation Foundation, Washington, D.C. 52 pp. 1970.
Note: new.
Clearly the effective way to protect fish and wildlife is not by restricting hunting or harassment alone, but by banning these vehicles from important habitats (p.25).

23. Baldwin, M. F. and D. H. Stoddard, Jr. THE OFF-ROAD VEHICLE AND ENVIRONMENTAL QUALITY: AN UPDATED REPORT ON THE SOCIAL AND ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES, PARTICULARLY SNOWMOBILES, WITH SUGGESTED POLICIES FOR THEIR CONTROL. 2nd ed. Conservation Foundation. Washington, D.C. 61 pp. 1973.
Note: new.

24. Baldwin, M. F. THE SNOWMOBILE AND ENVIRONMENTAL QUALITY. Living Wilderness; 32(104):14-17. 1968.
Recreational uses of snowmobiles is examined in terms of effects on environmental quality through noise, fumes, and impacts on fish, wildlife and trails. Harassment of wild game, nongame, and predators by snowmobile users is described. Policy recommendations are suggested and discussed (Boyle and Sampson 1983).

25. Banko, W. E. *THE TRUMPETER SWAN. N. Am. Fauna 63, U.S. Fish Wildl. Ser., Washington, D.C. 214 pp. 1960.
26. Basil, J. V.; and T. N. Lonner. VEHICLE RESTRICTIONS INFLUENCE ELK AND HUNTER DISTRIBUTION IN MONTANA. J. Forestry; 77:155-159. 1979.
27. Batcheler, C. L. COMPENSATORY RESPONSES OF ARTIFICIALLY CONTROLLED MAMMAL POPULATIONS. Proc. of the New Zealand Ecol. Soc.; 15:25-30. 1968.
28. Bayfield, N. G. SOME EFFECTS OF WALKING AND SKIING ON VEGETATION AT CAIRNGORM. J. Applied Ecology 7:469-485. 1970.
Note: new.
29. Bear, G. D.; and G. W. Jones. HISTORY AND DISTRIBUTION OF BIGHORN SHEEP IN COLORADO. Colorado Division of Wildlife, Denver, CO. 232 pp. 1973.
Available information on the history, distribution, population trends, and ecological factors for bighorn sheep herds in Colorado are summarized. Human influences are discussed for each of the herds; while few quantitative data are available, observations suggest that in many cases, such as camping, hiking, and driving off-road vehicles, influence sheep distributions and activities (Boyle and Sampson 1983).
30. Beier, P. DETERMINING MINIMUM HABITAT AREAS AND HABITAT CORRIDORS FOR COUGARS. Conserv. Biol. 7:94-108. 1993.
Note: new.
31. Belanger, L.; and J. Berdard. ENERGETIC COST OF MAN-INDUCED DISTURBANCE TO STAGING SNOW GEESE. J. Wildl. Manage.; 54:36-41. 1990.
32. Bell, J. N. WILD ANIMALS ARE WILD. Natl. Wildl.; 1(5):34-36. 1963.
Problems of human-wildlife interactions in National Parks are described in this popular article. Park visitors unaware of the potential hazards of confrontations with wildlife sometimes create dangerous situations by inappropriate behavior. Park visitors are entitled to wildlife viewing experiences, but must be educated about wildlife behavior and maintain respect for wild animals (Boyle and Sampson 1983).
33. Bennett, L. E. COLORADO GRAY WOLF RECOVERY: A BIOLOGICAL FEASIBILITY STUDY. Univ. Wyo. Coop. Fish Wildl. Res. Unit. Laramie. 318 pp. 1994.
34. Bennett, L. E. A REVIEW OF POTENTIAL EFFECTS OF WINTER RECREATION ON WILDLIFE IN GRAND TETON AND YELLOWSTONE NATIONAL PARKS: A BIBLIOGRAPHIC DATABASE. Final Report. Mimeo. Sponsored by U.S. National Park Service in cooperation with Univ. of Wyoming Cooperative Fish and Wildlife Research Unit, Laramie. 141 pp. 1995.
Note: new.
35. Berry, K. H. A REVIEW OF THE EFFECTS OF OFF-ROAD VEHICLES ON BIRDS AND OTHER VERTEBRATES. In: Management of Western Forests and Grasslands for Nongame Birds. Workshop Proceedings. U.S. For. Srv., Gen. Tech. Rep. INT-86, pp. 451-467. 1980.
Note: new.

36. Berwick, S. H. OBSERVATIONS ON THE DECLINE OF THE ROCK CREEK, MONTANA, POPULATION OF BIGHORN SHEEP. M.S. thesis; Univ. of Montana, Missoula. 245 pp. 1968.
Among factors that may be responsible for an observed decline in a Montana bighorn sheep population are human disturbance and harassment of sheep. Snowmobile use of an important segment of sheep winter range is increasing. It is suggested that harassment may be debilitating to winter-stressed animals (Boyle and Sampson 1983).

37. Bess, F. H. THE EFFECT OF SNOWMOBILE NOISE ON THE HEARING MECHANISM. Proceedings of the 1971 Snowmobile and Off-Road Vehicle Research Symposium. Sponsored by the Dept. of Park and Recreation Resources, Michigan State University, East Lansing. 1971.
Note: new.

38. Bird, D. M. BIRDS OF PREY: A PLEA FOR ETHICS. Ont. Nat.; 17(5):16-23. 1978.
Problems facing birds of prey are described in this nontechnical article. Effects of man on raptors are discussed, including impacts on research, wildlife photography, and bird watching. Disturbances of birds by these activities can cause adults to abandon nests, and decrease survival of eggs and young through predation or exposure. Education of public on the values of birds of prey is essential for their protection (Boyle and Sampson 1983).

39. Bissell, L. P. THE SOCIAL AND POLITICAL IMPACT OF SNOWMOBILES. In: Proceedings 3rd International Snowmobile Congress, Portland, Maine. pp.58-62. 1970.
Note: new.

40. Bjarvall, A. NORTH AMERICAN STUDIES ON THE EFFECTS OF SNOWMOBILES ON FAUNA. Flora Fauna. 1974.
Note: new.

41. Blackford, J. L. *WOODPECKER CONCENTRATION IN BURNED FOREST. Condor; 57:28-30. 1955.

42. Blangley, S. and M. E. Wood. DEVELOPING AND IMPLEMENTING ECOTOURISM GUIDELINES FOR WILDLANDS AND NEIGHBORING COMMUNITIES. In: Ecotourism: A Guide for Planners and Managers, K. Lindberg and D. E. Hawkins, eds., pp. 32-54. North Bennington, Vermont; The Ecoturism Society. 1993.
Note: new.

43. Blokpoel, H. AN ATTEMPT TO EVALAUTE THE IMPACT OF CANNON-NETTING IN CASPIAN TERN COLONIES. Colon. Waterbirds; 4:61-67. 1981.
From studies of Caspian terns on Lake Huron, Ontario, it was found that visits to tern colonies resulted in losses of eggs to predation by gulls. Human activities at tern nesting colonies should be restricted until more is known about the nature and extent of human-induced nest losses (Boyle and Sampson 1983).

44. Bock, C. E., and J. H. Bock. *ON THE GEOGRAPHICAL ECOLOGY AND EVOLUTION OF THE THREE-TOED WOODPECKERS. Am. Midl. Nat.; 92:397-405. 1974.

45. Bollinger, J. G., O. J. Rongstad, A. Soom, and R. G. Eckstein. SNOWMOBILE NOISE EFFECTS ON WILDLIFE. 1972-1973 report. Engineering Exp. Sta., Univ. of Wisconsin, Madison. 85pp. 1973.
Note: new.

46. Boucher, J., and T. A. Tattar. SNOWMOBILE IMPACT ON VEGETATION. Forest Notes 120:27-28. 1974.
Note: new.
47. Bowles, A. E. RESPONSES OF WILDLIFE TO NOISE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 109-156. Island Press, Washington, D.C. 1995.
Note: new.
48. Bowles, A., B. Tabachnick, and S. Fidell, eds. REVIEW OF THE EFFECTS OF AIRCRAFT OVERFLIGHTS ON WILDLIFE. National Park Service, Report No. 7500. 373 pp. 1991.
Note: new.
This three-volume compilation, with bibliography, reviews various studies conducted on the effects of aircraft noise on wildlife. A summary draws conclusions. Includes general disturbance factors.
49. Boyce, M. S. POPULATION VIABILITY ANALYSIS. Annu. Rev. Ecol. Syst. 23:481-506. 1992.
Note: new.
50. Boyce, M. S.; and L. D. Hayden-Wing. *NORTH AMERICAN ELK: ECOLOGY, BEHAVIOR AND MANAGEMENT. Univ. Wyo., Laramie. 294 pp. 1971.
51. Boyd, R. J. *AMERICAN ELK. Pages 10-29 in: J. D. Schmidt and D. L. Gilbert, eds. Big game of North America. Stackpole Books, Harrisburg, PA., and Wildl. Manage. Inst., Washington, D.C. 1978.
52. Boyle, S. A. and F. B. Samson. EFFECTS OF NONCONSUMPTIVE RECREATION ON WILDLIFE: A REVIEW. Wildlife Society Bull. 13(2):110-116. 1985.
Note: new.
A literature review of 536 references which showed negative effects for most types of recreational activity. Suggests four management alternatives including “sacrifice” areas.
53. Boyle, S. A. and F. B. Samson. EFFECTS OF NONCONSUMPTIVE RECREATION ON WILDLIFE: A REVIEW. Wildl. Soc. Bull. 13:110-116. 1985.
Note: new.
54. Boyle, S. A.; and F. B. Samson. NONCONSUMPTIVE OUTDOOR RECREATION: AN ANNOTATED BIBLIOGRAPHY OF HUMAN -WILDLIFE INTERACTIONS. USDI, U.S. Fish Wildl. Serv. Special Sci. Rep. No. 252. 1983.
*Annotated Bibliography.
55. Brand, C. J.; L. B. Keith; and C. A. Fischer. *LYNX RESPONSES TO CHANGING SNOWSHOE HARE DENSITIES IN CENTRAL ALBERTA. J. Wildl. Manage.; 40:416-428. 1976.
56. Budowski, G. TOURISM AND ENVIRONMENTAL CONSERVATION: CONFLICT, COEXISTENCE, OR SYMBIOSIS? Environ. Conserv.; 3:27-31. 1976.
Relationships between tourism and conservation are described as conflicting, coexisting, or symbiotic. Widespread environmental degradation has often resulted from tourism, as many places visited by tourists support fragile ecosystems. Proper attitudes and management schemes can lead to symbiotic relationships instead of conflicts (Boyle ans Sampson 1983).

57. Buehler, D. A.; T. J. Mersmann; J. D. Fraser; and J. K. D. Seegar. EFFECTS OF HUMAN ACTIVITY ON BALD EAGLE DISTRIBUTION ON THE NORTHERN CHESAPEAKE BAY. J, Wildl. Manage.; 55:282-290. 1991.

58. Buehler, D. A.; T. J. Mersmann; J. D. Fraser; and J. D. Seegar. NONBREEDING BALD EAGLE COMMUNAL AND SOLITARY ROSSTING BEHAVIOR AND ROOST HABITAT ON THE NORTHERN CHESAPEAKE BAY. J. Wildl. Manage. 55(2):273-281. 1990.

The authors studied roosting behavior and habitat use of nonbreeding bald eagles on the northern Chesapeake Bay during 1986-1989. Results of the study included the recommendation that a 1,360-m-wide shoreline management zone that extends 1,400 m inland should be provided to encompass roost sites and provide a buffer from human disturbance.

59. Buell, N. E. REFUGE RECREATION: HIGH STANDARDS EQUAL QUALITY. Living Wilderness; 31(98):24-26. 1967.

The role of U.S. National Wildlife Refuges in providing recreational opportunities is discussed in this popular article. Planning for recreation on refuges is based on the view that quality of experience rather than quantity of use is most desirable to visitors and protected wildlife. Responsibilities and approaches to recreation management are discussed (Boyle and Samson 1983).

60. Bull, E. L. *ECOLOGY OF THE PILEATED WOODPECKER IN NORTHEASTERN OREGON. J. Wildl. Manage.; 51(2):472-481. 1987.

61. Bull, E. L.; and M. G. Henjum. *THE NEIGHBORLY GREAT GRAY OWL. Natural History; 9:32-41. 1987.

62. Burger, J. THE EFFECT OF HUMAN ACTIVITY ON SHOREBIRDS IN TWO COASTAL BAYS IN NORTHEASTERN UNITED STATES. Environ. Conserv.; 13:123. 1986.

63. Burger, J. FORAGING BEHAVIOR AND THE EFFECTS OF HUMAN DISTURBANCE ON THE PIPING PLOVER. J. Coast. Res.; 7:39-52. 1991.

64. Burk, D. ed. *THE BLACK BEAR IN MODERN NORTH AMERICA. Proc. of the workshop on the management biology of the North American black bear, Kalispell, MT., 17-19 Feb 1977. Boone and Crockett Club, New York, and Amwell Press, Clinton, N.J. 300 pp. 1979.

65. Burkey, T. V. EXTINCTION IN NATURE RESERVES: THE EFFECT OF FRAGMENTATION AND THE IMPORTANCE OF MIGRATION BETWEEN RESERVE FRAGMENTS. Oikos 55:75-81. 1989.

Note: new.

66. Bury, R. EFFECTS OF OFF-ROAD VEHICLES ON DESERT VERTEBRATES. Bulletin of the Ecological Society of America 56(2):40. 1975.

Note: new.

67. Bury, R. B., R. A. Luckenbach, and S. D. Busak. EFFECTS OF OFF-ROAD VEHICLES ON VERTEBRATES IN CALIFORNIA. USDI Fish & Wildlife Service. 1977.
Note: new.
Compared 8 paired sites. ORV use areas had significantly fewer species of vertebrates, reduced numbers of individuals and lower reptile and small mammal biomass. Censuses also showed decreased diversity, density, and biomass estimates of breeding birds in ORV used areas.

68. Bury, R. L. IMPACTS OF SNOWMOBILES ON WILDLIFE. Trans. N. Am. Wildl. Nat. Resour. Conf.; 43:149-156. 1978.
Existing research on snowmobile-wildlife interactions and future research needs are discussed (Boyle and Sampson 1983).

69. Bury, R. L. OFF-ROAD RECREATION VEHICLES: RESEARCH RESULTS AND ADMINISTRATIVE REPORTS, AND TECHNICAL ARTICLES, 1970-1975. Council of Planning Librarians, Monticello, Ill., Exch Biblio. 1067. 23 pp. 1976.
*Bibliography.

70. Bury, R. B. WHAT WE KNOW AND DO NOT KNOW ABOUT OFF-ROAD VEHICLE IMPACTS ON WILDLIFE. Page 110-122 in: R. N. L. Andrews; and P. F. Nowak, eds. Off-road vehicle use: A management challenge. Conf. Proc., 16-18 March 1980, Ann Arbor, MI. 1980.
Research concerning off-road vehicle impacts on wildlife is reviewed to illustrate the levels of impacts and to provide guidance for more effective protection of wildlife in off-road vehicle areas. Effects on wildlife include direct mortality, damage to vegetation, disruption of soil, and noise harassment. Research and management recommendations are suggested (Boyle and Sampson 1983).

71. Bury, R. L.; S. F. McCool; and R. J. Wendling. RESEARCH ON OFF-ROAD VEHICLES: A SUMMARY OF SELECTED REPORTS AND A COMPREHENSIVE BIBLIOGRAPHY. Pages 234-272, in: Proc. of the Southern States Recreation Research Applications Workshop, 15-18 September 1975, Asheville, NC. U.S. For, Serv. Gen. Tech. Rep. SE-9. 1976.
Bibliography.

72. Busnel, R. G. EFFECTS OF NOISE ON WILDLIFE: INTRODUCTION. Pages 7-22 in: J. L. Fletcher and R. G. Busnel. 1978.
This introductory article reviews some aspects of animal behavior associated with noise, citing examples from scientific literature and anecdotal observations. Theoretical approaches and aspects of policy relating to noise effects and the conservation of wildlife are discussed (Boyle and Sampson 1983).

73. Buss, I. O.; and A. S. Hawkins. *THE UPLAND PLOVER AT FAVILLE GROVE, WISCONSIN. Wilson Bull.; 51:202-220. 1939.

74. Butcher, D. SNOWMOBILES AND THE NATIONAL PARKS. Am For.; 78(4):28-31, 46-49. 1972.
The author cites Congressional testimony, popular literature, and personal experiences to document environmental impacts of snowmobiles, including impacts on wildlife. Habitat destruction and deliberate harassment of animals are noted. The author calls for the prohibition of snowmobiles and other off-road vehicles in National Parks to protect the environment and ensure the satisfaction of other park visitors (Boyle and Sampson 1983).

75. Cade, T. J.; J. H. Enderson; C. G. Thelander; and C. M. White. *PEREGRINE FALCON POPULATIONS: THEIR MANAGEMENT AND RECOVERY. The Peregrine Fund, Inc., Boise. 949 pp. 1988.

76. Call, M. W. HABITAT MANAGEMENT FOR BIRDS OF PREY. U.S.D.I; Bureau of Land Management, Tech. Note 338. 70pp. 1979.
Habitat management considerations for birds of prey are reviewed. Human activities that should be controlled in nesting and roosting areas include recreational activities; many areas preferred by humans for recreation are important raptor nesting sites as well. Management considerations include siting recreational developments away from important raptor habitats, and restricting human activities during the breeding season (Boyle and Sampson 1983).

77. Cannon, H. L. and J. M. Bowles. CONTAMINATION OF VEGETATION BY TETRAETHYL LEAD. Science 137:765-766. 1988.
Note: new.

78. Carbyn, L. N. WOLF POPULATION FLUCTUATIONS IN JASPER NATIONAL PARK, ALBERTA, CANADA. Biol. Consev.; 6(2):94-101. 1974.
Population fluctuations mainly a result of human pressures in areas adjacent to park. Population negatively affected by disturbance at den site and high percentage of ungulates on heavily traveled roads as wolves tend to avoid traveled roads.

79. Carbyn, L. N. *WOLF PREDATION OF ELK IN RIDING NATIONAL PARK, MANITOBA. J. Wildl. Manage.; 47(4):977-988. 1983.

80. Casey, D. *AMERICAN MARTEN. Dodd-Mead, New York. 64 pp. 1988.

81. Cassirer, E. F. RESPONSES OF ELK TO DISTURBANCE BY CROSS-COUNTRY SKIERS IN NORTHERN YELLOWSTONE NATIONAL PARK. M. S. Thesis, Univ. of Idaho, Moscow. 101 pp. 1990.
Note: new.

82. Cassirer, E. F.; D. J. Freddy; and E. D. Ables. ELK RESPONSES TO DISTURBANCE BY CROSS-COUNTRY SKIERS IN YELLOWSTONE NATIONAL PARK. Wildl. Soc. Bull.; 20:375-381. 1992.
The objectives of this study were to measure the immediate movements of elk when disturbed by cross-country skiers, to assess energy costs associated with these movements, and to identify factors that might influence elk behavior. The results of this disturbance study indicate that restricting cross-country skiers to locations > 650 m from elk wintering areas would probably minimize displacement of most nonhabituated elk by skiers on shrub steppe and upland steppe winter ranges similar to that in Yellowstone. Seventy-five percent of nonhabituated elk flight responses in northern Yellowstone occurred within 650 m. Skiers would likely have to remain at distances of >1,700 m to completely avoid disturbing elk. The amount of winter range used by skiers and the number of days involved seemed to be more important than skier numbers.

83. Chapman, R. C. THE EFFECTS OF HUMAN DISTURBANCE ON WOLVES. M.S. thesis; Univ. Alaska, Fairbanks 209 pp. 1977.
Wolves responded to humans near pups by barking or howling, leaving the area, or moving the pups. Low intensity disturbance does not seem to cause significant pup mortality. Recommends closing areas of 2.4 km radius around homesites to disturbance from 4 or 5 weeks before whelping until wolves leave the area. Contains appendix of more than 100 published and unpublished accounts of wolf/man interactions (Ream 1980).

84. Chappel, R. W. and R. J. Hudson. PREDICTION OF ENERGY EXPENDITURES BY ROCKY MOUNTAIN BIGHORN SHEEP. Can. J. Zool. 58:1908-1912. 1980.
Note: new.

85. Chester, J. M. HUMAN WILDLIFE INTERACTIONS IN THE GALLATIN RANGE, YELLOWSTONE NATIONAL PARK, 1973-1974. M.S. thesis; Montana State Univ., Bozeman. 114 pp. 1976.
Relationships between human use and the distribution, movements, and behavior of seven species of wildlife in the backcountry of the Gallatin Range, Yellowstone National Park, were investigated. Variation in the intensity of human use was rarely responsible for shifts in wildlife distribution. Wildlife belligerency towards humans was rare, although back-country travelers tended to engage in activities that could increase detrimental encounters with wildlife (Boyle and Samson 1983).

86. Clark, T. W. *ANALYSIS OF PINE MARTEN POPULATION ORGANIZATION AND REGULATORY MECHANISMS IN JACKSON HOLE, WYOMING. Nat. Geogr. Soc. Research Report; 1982:131-143. 1982.

87. Clark, T. W.; E. Anderson; C. Douglas; and M. Strickland. *MARTES AMERICANA. Mammalian Species No. 289:1-8. 1987.

88. Clark, T. W.; A. H. Harvey, R. D. Dorn; D. L. Genter; and C. Groves, eds. RARE, SENSITIVE, AND THREATENED SPECIES OF THE GREATER YELLOWSTONE ECOSYSTEM. Northern Rockies Conservation Cooperative, Montana Natural Heritage Program, The Nature Conservancy, and Mountain West Environmental Services. 153 pp. 1989.
This report gives a description, range, habitat, life history and ecology, and conservation needs of each rare, sensitive, and threatened species (animal and plant) associated with the Greater Yellowstone Ecosystem (GYE).

89. Clark, T.; M. Bekoff; T. M. Campbell; and T. Hauptman. AMERICAN MARTEN, MARTES AMERICANA, HOME RANGES IN GRAND TETON NATIONAL PARK, WYOMING. Canadian Field-Nat.; 103(3):423-425. 1988.

90. Clevenger, G. A.; and G. W. Workman. THE EFFECTS OF CAMPGROUNDS ON SMALL MAMMALS IN CANYONLANDS AND ARCHES NATIONAL PARKS, UTAH. Trans. N. Am. Wildl. Nat. Resour. Conf.; 42:473-484. 1977.
Small mammal studies in 2 National Parks in Utah indicated that campgrounds may have significant effects on populations of small mammals inhabiting them. Additional food available at campgrounds may be partly responsible for larger populations observed in campgrounds (Boyle and Samson 1983).

91. Cole, D. N. and P. B. Landres. INDIRECT EFFECTS OF RECREATIONISTS ON WILDLIFE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 183-202. Island Press, Washington, D.C. 1995.
Note: new.
92. Cole, D. L. and R. L. Knight. WILDLIFE PRESERVATION AND RECREATIONAL USE: CONFLICTING GOALS OF WILDLIFE MANAGEMENT. Tran. N. Am. Wildl. Nat. Res. Conf. 56:233-237. 1991.
Note: new.
93. Cole, David N. WILDERNESS RECREATION MANAGEMENT. J. For.; 91(2):224. 1993.
94. Cole, David L. WILDLIFE PRESERVATION AND RECREATIONAL USE:CONFLICTING GOALS OF WILDLIFE MANAGEMENT. Trans. N. Am. Wildl. Nat. Resour. Conf.; No. 5 p. 233-237. 1991.
95. Cole, G. F. GRIZZLY BEAR–ELK RELATIONSHIPS IN YELLOWSTONE NATIONAL PARK. J. Wildl. Mgmt. 36(2):556-561. 1972.
Note: new.
96. Connolly, G. E. *LIMITING FACTORS AND POPULATION REGULATION. Pages 245-285 in: O. A. Wallmo, ed. Mule and Black-tailed deer of North America. Univ. Neb. Press, Lincoln. 1981.
97. Connolly, G. E.; and D. C. Wallmo. *MANAGEMENT CHALLENGES AND OPPORTUNITIES. Pages 537-545 in: O. C. Wallmo, ed. Mule and black-tailed deer of North America. Univ. Neb. Press, Lincoln. 1981.
98. Conrad, A. H. WILDERNESS PRESERVATION, PLANNING AND MANAGEMENT: AN ANNOTATED BIBLIOGRAPHY. Council of Planning Librarians, Monticello, Ill., Exch. Biblio. 1515. 54 pp. 1978.
*Annotated Bibliography.
99. Cooke, A. S. OBSERVATIONS ON HOW CLOSE CERTAIN PASSERINE SPECIES WILL TOLERATE AN APPROACHING HUMAN IN RURAL AND SUBURBAN AREAS. Biological Conservation 18:85. 1980.
Note: new.
100. Corbet, P. S. SNOWMOBILES: FOR PLEASURE, PROFIT, AND POLLUTION. Ont. Nat.; 8(2):10-12. 1970.
Impacts of snowmobiles on urban and rural environments, including effects on wildlife, are discussed in this nontechnical article. Snowmobiles compact snow, changing the physical and thermal properties and thus potentially affecting animals that live beneath snow in winter. Deliberate harassment of wildlife by snowmobilers is uncommon but may be significant. Effective legislation and enforcement are needed to control the impacts of snowmobiles on the environment (Boyle and Samson 1983).
101. Corbus, M. MOOSE AS AN AESTHETIC RESOURCE AND THEIR SUMMER FEEDING BEHAVIOR. Am. Moose Conf. Workshop 8:244-273. 1972.
A moose herd in Sibley Provincial Park, Ontario, is described as an appreciative resource used by many campers who go there specifically to view moose. Responses of moose to the presence of humans and aspects of the resource users are discussed (Boyle and Samson 1983).

102. Craig, G. *PEREGRINE FALCON. Pages 807-826 in: Audubon Wildlife Report 1986. The National Audubon Society, Washington, D.C. 1986.

103. Craighead, F. C., Jr; and J. J. Craighead. DATA ON GRIZZLY BEAR DENNING ACTIVITIES AND BEHAVIOR OBTAINED BY WILDLIFE TELEMETRY. Pages 84-106 in: S. Herrero, ed. Bears—their biology and management, 6-9 November 1970, Calgary, Alberta. IUCN Publ. New Ser. 23, Morges, Switzerland. 1972.
Denning behavior of telemetered grizzly bears was studied in Yellowstone National Park. Observations suggested that grizzlies do not actively defend dens from other bears or humans if alternate courses of action are available. Most grizzlies apparently prefer to avoid humans; the most dangerous bears are those that have been wounded, sows with cubs, and those that have learned to associate food with humans (Boyle and Samson 1983).

104. Craighead, J. J., G. Atwell and B. W. O'Gara. ELK MIGRATIONS IN AND NEAR YELLOWSTONE NATIONAL PARK. Wildl. Monog. 29. 48 pp. 1972.
Note: new.

105. Craighead, J. J.; and F. C. Craighead, Jr. GRIZZLY BEAR-MAN RELATIONSHIPS IN YELLOWSTONE NATIONAL PARK. BioScience; 21:845-857. 1971.
Results are reported of 12 years of research on grizzly bears and their relationships with man in Yellowstone National Park and surrounding national forests. The chance for injury from grizzly bears is very small, but grizzly attacks provide exciting news and generate an exaggerated public response, which in turn may initiate over-reactionary bear control measures harmful to bear-human coexistence. Management must be carefully tailored to the facts of bear behavior, while visitors must be willing to accept a small risk (Boyle and Samson 1983).

106. Craighead, J. J.; J. R. Varney; and F. C. Craighead. *A POPULATION ANALYSIS OF THE YELLOWSTONE GRIZZLY BEARS. Mt. For. Cons. Exp. Sta. Bull.; No 40. 40 pp. 1974.

107. Cryer, M.; R. M. Ward; J. O. Stafford; and P. F. Randerson. DISTURBANCE OF OVERWINTERING WILDFOWL BY ANGLERS AT TWO RESEVOIR SITES IN SOUTH WALES. Bird Study; 34:191-199. 1987.

108. Curtis, S. HOW TO TRACK WILDLIFE ON SKIS. Backpacker 2(4):40-45, 79-80, 83. 1974.
Recommends techniques for approaching wildlife in winter for observation and photography. Warns of negative effects of disturbance on wintering wildlife. Cites snowmobile harassment of ungulates (Ream 1980).

109. Dahlgren, R. B.; and C. E. Korschgen. HUMAN DISTURBANCES OF WATERFOWL. USDI, U.S. Fish Wildl. Serv. Res. Pub. 188. 62 pp. 1992.
Annotated Bibliography.

110. Dalle-Molle, J.; and J. Van Horn. OBSERVATION OF VEHICLE TRAFFIC INTERFERING WITH MIGRATION OF DALL'S SHEEP, OVIS DALLI DALLI, IN DENALI NATIONAL PARK, ALASKA. Canadian Field-Nat.; 105(3):409-411.
Two observations of Dall's sheep groups unsuccessfully attempting to cross the Denali National Park Road, during a seasonal migration, are described. Where the road passes through sheep range, sheep have habituated to the traffic and readily cross. Sheep occupying ranges away from the road must cross the road during seasonal migrations and have not habituated to traffic, even though the road has been there for 54 years.

111. Daon, K. H. EFFECT OF SNOWMOBILES ON FISH AND WILDLIFE RESOURCES. Conv. Int. Assoc. Game Fish Conserv. Comm.; 60:97-103. 1970.
Increases in demand for snowmobiles and potential impacts on fish and wildlife resources are reviewed. Impacts of snowmobiles are listed as benefits and liabilities; other sections discuss registration, regulation, and education of snowmobile users (Boyle and Samson 1983).

112. Davy, B. A. and B. H. Sharp. CONTROL OF SNOWMOBILE NOISE. Environmental Protection Agency, Ofc. of Noise Abatement and Control. Springfield, VA. 1984.
Note: new.

113. DeForge, J. R. STRESS: IS IT LIMITING BIGHORN? Trans. Desert Bighorn Council; 20:30-31. 1976.
The bighorn sheep is an ice-age mammal that has become highly specialized, evolving essentially outside the influence of man. Today, however, human encroachment on sheep habitats and disturbance of populations result in stress in bighorns, forcing them to adapt socially. Stress, frequently human-induced, appears to be a major limiting factor in the bighorn's struggle for survival (Boyle and Samson 1983).

114. deGroot, R. W. TOURISM AND CONSERVATION IN THE GALAPAGOS. Biological Conservation 26:291-300. 1983.
Note: new.

115. Delgiudice, G. D.; F. J. Singer; and U. S. Seal. PHYSIOLOGICAL ASSESSMENT OF WINTER NUTRITIONAL DEPRIVATION IN ELK OF YELLOWSTONE NATIONAL PARK. J. Wildl. Manage.; 55(4):653-664. 1991.
During 13 January-29 March 1988, the authors assessed the extent of nutritional deprivation in cow elk groups on the lower, middle, and upper Northern Range and on the Madison-Firehole Range in Yellowstone National Park by 4 sequential collections and chemical analyses of urine excreted in snow (snow-urine). Throughout winter, snow-urine samples with metabolic profiles indicative of severe energy deprivation and accelerated degradation of lean body tissue were most apparent in areas associated with increased elk density and/or deep snow cover.

116. DeMarchi, R. REPORT AND RECOMMENDATIONS OF THE WORKSHOP ON CALIFORNIA BIGHORN SHEEP. Pages 143-163 in: J. B. Trefethen ed. The wild sheep in modern North America. Boone and Crockett Club and the Winchester Press, NY. 1975.
Objectives and procedures for management of California bighorn sheep for consumptive and nonconsumptive uses are described. Protection of bighorn sheep includes regulating off-road vehicles and human activities such as hiking, camping. picknicking, and sightseeing. Noncosumptive recreational uses of bighorn sheep are recognized as valuable and important criteria (Boyles and Samson 1983).

117. Denniston, R. H. ECOLOGY, BEHAVIOR AND POPULATION DYNAMICS OF THE WYOMING OR ROCKY MOUNTAIN MOOSE. Zoologica (NY); 41:105-118. 1956.
This report of ecological studies of moose in Wyoming includes sections on man-moose interactions. Moose were found to be tolerant of close observers when no quick motions or loud noises were made. Cases of moose aggression toward people and automobiles are noted (Boyle and Samson 1983).

118. Despain, D. D. Houston, M. Meagher, and P. Schullery. WILDLIFE IN TRANSITION: MAN AND NATURE ON YELLOWSTONE'S NORTHERN RANGE. Roberts Rinehart. Boulder, Colo. 142 pp. 1986.
Note: new.

119. Dice, E. F. EFFECTS OF SNOWMOBILING ON ALFALFA, TREES (PINUS RESINOSA, PINUS BANKSIANA) AND SOIL BACTERIA. Ext. Bull. Michigan State Coop. Ext. Serv. East Lansing, Mich. 1976.
Note: new.

120. Diem, K. L. WHITE PELICAN REPRODUCTIVE FAILURES IN THE MOLLY ISLANDS BREEDING COLONY IN YELLOWSTONE NATIONAL PARK. In: R. M. Linn, ed. Proc. of the 1st Conf. on Sci. Res. in the Nat. Parks. National Park Serv. Trans. and Proc. Series No. 5:489-496. 1979.

121. Diem, K. L.; and D. D. Condon. BANDING STUDIES OF WATERBIRDS ON THE MOLLY ISLANDS, YELLOWSTONE LAKE, WYOMING. Yellowstone Library and Museum Assoc., Yellowstone National Park, WY. 41 pp. 1967.

122. Dixon, K. R. and J. A. Chapman. HARMONIC MEAN MEASURE OF ANIMAL ACTIVITY AREAS. Ecology 6:1040-1044. 1980.
Note: new.

123. Doan, K. H. EFFECT OF SNOWMOBILES ON FISH AND WILDLIFE RESOURCES. Int. Assoc. Game Fish Conservation Commissioners Convention 60:97-103. New York. 1970.
Note: new.

124. Dorrance, M. J.; P. J. Savage; and D. E. Huff. EFFECTS OF SNOWMOBILES ON WHITE-TAILED DEER. J. Wildl. Manage.; 39(3):563-569. 1975.
In studies of white-tailed deer in Minnesota, deer responded to very low intensities of intrusion by man and snowmobiles. Displacement of deer from areas along trails occurred; in some cases changes in home range size and increased movement were observed. It is suggested that the observed disturbances could be detrimental to deer, especially during severe winters.

125. Douglas, C. W.; and M. A. Strickland. *FISHER. Pages 511-529 in: M. Novak, J. A. Baker, M. E. Obbard. and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario. 1987.

126. Drewien, R. C. *THE SANDHILL CRANE IN WYOMING. Wyoming Wildl.; 37(7):20-25. 1973.

127. Drewien, R. C.; and E. G. Bizeau. *STATUS AND DISTRIBUTION OF THE GREATER SANDHILL CRANE IN THE ROCKY MOUNTAINS. J. Wildl. Manage.; 38:720-742. 1974.

128. Drewien, R. C.; W. M. Brown; and J. D. Varley. THE GREATER SANDHILL CRANE IN YELLOWSTONE NATIONAL PARK: A PRELIMINARY SURVEY. Pages 27-38 in: J. C. Lewis and J. W. Ziewitz, eds. Proc. 1985 Crane Workshop. Platte River Whooping Crane Maintenance Trust and U.S, Fish and Wildlife Service, Grand Island, NE. 1987.

129. Driver, B. L. and P. J. Brown. THE OPPORTUNITY SPECTRUM CONCEPT AND BEHAVIORAL INFORMATION IN OUTDOOR RECREATION SUPPLY INVENTORIES: A RATIONALE. In: Integrated Inventories and Renewable Natural Resources. Proceedings of the Workshop, eds. Lund, H.G. et al., 24-31. General Tech. Report RM-55. Fort Collins, Colo. U.D. Dept. Agric., Forest. 1978.
Note: new.

130. Dufour, P. EFFECTS OF NOISE ON WILDLIFE AND OTHER ANIMALS. Memphis State University, for United States Environmental Protection Agency, NTID 300.5. 1971.
Note: new.
Data for domestic and laboratory animals was extrapolated for wildlife. Potential impacts included masking of signals and calls. Chronic exposure could result in physiological and behavioral changes. Effects would most likely be cumulative.

131. Dunaway, D. J. HUMAN DISTURBANCE AS A LIMITING FACTOR OF SIERRA NEVADA BIGHORN SHEEP. Trans. N. Am. Wild Sheep Conf.; 1:165-173. 1971.
Disturbance caused by human recreation is suggested as a factor limiting populations of bighorn sheep in California. Three populations that have declined were in areas of increased recreational use; two other stable populations have suffered less disturbance by recreationists (Boyle and Samson 1983).

132. Dunning, J. B., B. J. Danielson, and H. R. Pulliam. ECOLOGICAL PROCESSES THAT AFFECT POPULATIONS IN COMPLEX LANDSCAPES. Oikos 65:169-175. 1992.
Note: new.

133. Dunstan, T. C. THE BIOLOGY OF OSPREYS IN MINNESOTA. Loon; 45:108-113. 1973.
Results of 10 years of osprey research are summarized. While the effects of human disturbance to osprey productivity are difficult to evaluate, observations suggest that ospreys are sensitive to human interference, especially during incubation. Some nest abandonments have followed increased summer recreational use of the areas by boaters and fishermen (Boyle and Samson 1983).

134. Dunstan, T. C. BREEDING SUCCESS OF OSPREY IN MINNESOTA FROM 1963 TO 1968. Loon; 40:109-112. 1968.
The author reports results of his own studies plus observations gathered from several sources concerning osprey breeding success in Minnesota. Records indicate that human disturbance is a significant factor in reducing osprey productivity. Disturbances by direct shooting and by chilling or overheating of eggs when adults are frightened from nests are recorded (Boyle and Samson 1983).

135. Eckstein, R. G. and O. J. Rongstad. EFFECTS OF SNOWMOBILES ON THE MOVEMENTS OF WHITE-TAILED DEER IN NORTHERN WISCONSIN. Proc. Midwest Fish and Wildl. Conf. 35-39. 1973.
Note: new.

136. Eckstein, R. G.; T. F. O'Brien; O. J. Rongstad; and J. G. Bollinger. SNOWMOBILE EFFECTS ON MOVEMENTS OF WHITE-TAILED DEER: A CASE-STUDY. Environ. Conserv.; 6:45-51. 1979.
Effects of snowmobiles on winter home ranges, movements, and activity patterns of white-tailed deer were studied in Wisconsin. Daily activity patterns, home range size, and habitat use were little affected by snowmobiles. the impact of snowmobiles on deer appears to be minimal, but routing trails away from deer concentration areas in winter is suggested (Boyle and Samson 1983).

137. Edge, W. D.; and C. L. Marcum. MOVEMENTS OF ELK IN RELATION TO LOGGING DISTURBANCES. J. Wildl. Manage.; 49(4):926-930. 1985.
The objective of this study was to quantify the home ranges of nonmigratory cow elk, and to assess the effect of logging activities on home-range fidelity in the Chamerlain Creek area about 56 km east of Missoula, Montana. Results of the study indicate that cow elk will not abandon traditional home ranges because of logging activity when extensive areas of cover remain within their home range. Disturbances may alter habitat selection by increasing use of areas that provide cover, but this will occur within the traditional home range. In areas where cover is limited, logging activity may increase home-range size and reduce home-range fidelity. If closed areas are provided adjacent to all sides of active logging sales, disturbed home ranges will more likely contain security zones for elk. Logging activities that are restricted as much as possible in time and space, or conducted on seasonal ranges during when the elk are not present, will be least disruptive.

138. Edge, W. D.; C. L. Marcum; and S. L. Olson. EFFECTS OF LOGGING ACTIVITIES ON HOME-RANGE FIDELITY OF ELK. J. Wildl. Manage.; 49(3):741-744. 1985.

139. Edington, J. M.; and A. M. Edington. ECOLOGY, RECREATION AND TOURISM. Cambridge Univ. Press, Cambridge. 200 pp. 1986.

140. Elder, J. M. HUMAN INTERACTIONS WITH SIERRA NEVADA BIGHORN SHEEP: THE MOUNT BAXTER HERD. M.S. thesis; Univ. of Michigan, Ann Arbor. 93 pp. 1977.
A project begun in 1976 studied human disturbance of bighorn sheep in California. Human use of the area included backpacking and climbing. Hikers camped in very limited areas associated with the trail, water, and trees; climbers had the greatest potential effects on sheep. the levels of intrusion did not appear to be adversely affecting sheep, but if the number is allowed to increase the effects on sheep should be closely monitored (Boyle and Samson 1983).

141. Elgmark, K. and A. Langeland. POLLUTED SNOW IN SOUTHERN NORWAY DURING WINTERS 1968-1971. Environ. Pollution 4:41-52. 1973.
Note: new.

142. Enderson, J. H.; and J. Craig. STATUS OF THE PEREGRINE FALCON IN THE ROCKY MOUNTAINS. Auk; 91:727-736. 1974.
Factors responsible for an apparent decline in the numbers of peregrine falcons in the central Rocky Mountains are discussed. Pesticides appear to be the major factor; human disturbances such as rock climbing, picknicking, and highways may be important locally but are not widespread enough to explain the general decline (Boyle and Samson 1983).

143. Enger, P. S., H. E. Karlsen, F. R. Knudsen, and O. Sand. DETECTION AND REACTION OF FISH TO INFRASOUND. ICES Marine Sciences Symposia 196:108-112. 1993.
Note: new.
144. Erlich, P. R. EXTINCTION: WHAT IS HAPPENING NOW AND WHAT NEEDS TO BE DONE. In: Dynamics of Extinction, D. K. Elliott, ed., pp. 157-164. John Wiley and Sons, New York. 1986.
Note: new.
145. Escherich, P. C.; and L. Blum, eds. *PROC. BOBCAT RESEARCH CONF. National Wildlife Federation Scientific and Technical Series 6, Washington, D.C. 1979.
146. Evans, D. L. *STATUS REPORTS ON TWELVE RAPTORS. USDI, U.S. Fish Wildl. Serv. Special Sci. Rep. No. 238, Washington, D.C. 68 pp. 1982.
147. Fahrig, L. and G. Merriam. HABITAT PATCH CONNECTIVITY AND POPULATION SURVIVAL. Ecology 66:1762-1768. 1985.
Note: new.
148. Fancy, S. G.; and R. G. White. ENERGY EXPENDITURES BY CARIBOU WHILE CRATERING IN SNOW. J. Wildl. Manage.; 49(4):987-993. 1985.
The rate of energy expenditure by caribou digging in snow for lichens was determined by heart rate telemetry and an analysis of cratering mechanics. Based on a significant linear relationship between energy expenditure and heart rate, the mean cost per digging stroke in light, uncrusted snow was 118 J, whereas in denser (0.36 g/sq.cm) snow with a thin, hard crust the mean cost was 219 J/stroke. The cost of cratering through snow compacted by a snowmobile was 481 J/stoke. A comparison of metabolic and mechanical energy required for cratering suggested that caribou have evolved an energetically-efficient mechanism for obtaining food from beneath the snow layer.
149. Fay, R. R. HEARING IN VERTEBRATES: A PSYCHOPHYSICS DATABOOK. Hill-Fay Associates. Winnetka, Ill. 621 pp. 1988.
Note: new.
150. Fenton, M. B.; and G. P. Bell. *ECHOLOCATION AND FEEDING BEHAVIOR OF FOUR SPECIES OF MYOTIS (CHIROPTERA). Can. J. Zool.; 57:1271-1277. 1979.
151. Ferguson, M. A. D. and L. B. Keith. INFLUENCE OF NORDIC SKIING ON DISTRIBUTION OF MOOSE AND ELK IN ELK ISLAND NATIONAL PARK, ALBERTA. Can. Field-Nat. 99:69-78. 1982.
Note: new.
152. Ferguson, M. A.; and L. B. Keith. INTERACTIONS OF NORDIC SKIERS WITH UNGULATES IN ELK ISLAND NATIONAL PARK. Alberta Fish Wildl. Div. Wildl. Tech. Bull.; No. 6 31pp. 1981.

153. Fernandez, C.; and P. Azkona. HUMAN DISTURBANCE AFFECTS PARENTAL CARE OF MARSH HARRIERS AND NUTRITIONAL STATUS OF NESTLINGS. J. Wildl. Manage.; 57(3):602-608. 1993.

The authors studied the effects of human disturbance on parental care by marsh harriers (Cirus aeruginosus) in spring 1991 at Dos Reinos Lake, Ebro Valley, Spain. They assessed changes in reproductive activities and nutritional condition of nestlings due to low-level human disturbance during incubation and nestling phases. The number of food items delivered and the time spent by males and females in the nesting area and on the nest decreased during disturbed periods, especially during incubation, whereas behaviors related to stress (alarm calls, chases against other intruding birds, and percentage flying time) increased. Although annual productivity of the disturbed pairs was not affected, nestlings of disturbed birds exhibited levels of blood urea that were higher than those of undisturbed pairs. Thus, minor human disturbances may cause long-term effects on lifetime reproductive success of birds by increasing energy and time expenditure in non-reproductive activities and by reducing condition of nestlings.

154. Ferrin, R. S. and G. P. Coltharp. LEAD EMISSIONS FROM SNOWMOBILES AS A FACTOR IN LEAD CONTAMINATION OF SNOW. Proceedings of the Utah Academy of Science, Arts and Letters 51(1):116-118. 1974.

Note: new.

155. Findholt, S. L. STATUS AND DISTRIBUTION OF HERONS, EGRETS, IBISES AND RELATED SPECIES IN WYOMING. Colonial Waterbirds; 7:55-62. 1984.

156. Findholt, S. L.; and K. L. Diem. STATUS AND DISTRIBUTION OF AMERICAN WHITE PELICAN COLONIES IN WYOMING: AN UPDATE. Great Basin Nat.; 48:285-289. 1988.

157. Findholt, S. L.; and K. L. Berger. UPDATE ON THE STATUS AND DISTRIBUTION OF COLONIALLY NESTING WATERBIRDS IN WYOMING. Nongame Special Report, Wyoming Game and Fish Dept. 40 pp. 1987.

158. Fitts-Cochrane, J. LONG-BILLED CURLEW HABITAT AND LAND USE RELATIONSHIPS IN WESTERN WYOMING. M.S. thesis; Univ. Wyo., Laramie. 136 pp. 1983.

159. Fletcher, J. L. and R. G. Busnel, eds. EFFECTS OF NOISE ON WILDLIFE. Academic Press, Inc., New York. 1978.

Note: new.

Several papers, including a symposium on the effects on wildlife, quantifying the acoustic dose when determining the effects of noise on wildlife, and a perspective of government and public policy regarding noise and animals.

160. Foin, T. C., E. O. Garton, C. W. Bowen, J. M. Everingham, R. O. Schultz, and B. Holton, Jr. QUANTITATIVE STUDIES OF VISITOR IMPACTS ON ENVIRONMENTS OF YOSEMITE NATIONAL PARK, CALIFORNIA, AND THEIR IMPLICATIONS FOR PARK MANAGEMENT POLICY. Journal of Environmental Management 5:1-22. 1977.

Note: new.

161. Foresman, C. L., D. K. Ryerson, R. F. Johannes, W. H. Paulson, R. E. Rand, G. H. Tenpas, D. A. Schlough, and J. W. Pendleton. EFFECTS OF SNOWMOBILE TRAFFIC ON NON-FOREST VEGETATION: SECOND REPORT. School of Natural Resources, Univ. of Wisconsin, Madison, Wisc. 1973.

Note: new.

162. Foresman, K. R. *SOREX HOYI IN IDAHO: A NEW STATE RECORD. Murrelet; 67:81-82. 1987.

163. Franklin, A. B. *BREEDING BIOLOGY OF THE GREAT GRAY OWL IN SOUTHEASTERN IDAHO AND NORTHWESTERN WYOMING. Condor: 90:689-696. 1988.

164. Fraser, J. D.; L. D. Frenzel; and J. E. Mathisen. THE IMPACT OF HUMAN ACTIVITIES ON BREEDING BALD EAGLES IN NORTH-CENTRAL ILLINOIS. J. Wildl. Manage.; 49:585-592. 1985.

165. Fraser, J. D.; L. D. Frenzell; and J. E. Mathisen. THE IMPACT OF HUMAN ACTIVITIES ON BREEDING BALD EAGLES IN NORTH-CENTRAL MINNESOTA. J. Wildl. Manage.; 49(3):585-592. 1985.

The impacts of human activities and eagle management practices on bald eagle nesting biology were studied on Chippewa National forest in north-central Minnesota. Nests built on developed shoreline were farther away from water than nests built on undeveloped shoreline. Breeding eagles flushed at 57-991 m at the approach of a pedestrian. Fixed-wing aircraft passing 20-200 m from nests did not flush incubating or brooding eagles. The authors found no evidence that, under present management policies, human activities have an important impact on bald eagle reproductive success on the Chippewa National Forest.

166. Freddy, D. J. DEER-ELK INVESTIGATIONS: SNOWMOBILE HARASSMENT OF MULE DEER ON COLD WINTER RANGES. Colo. Div. Wildl Project W-038-R-32/WP14/J11. 15 pp. 1977.

Two semi-tame telemetered mule deer were experimentally harassed by one person, two persons, person plus a dog, and a snowmobile at various distances. Deer reactions to harassment were noted. Heart rate measured by telemetery was found to be sensitive measure of disturbance (Boyle and Samson 1983).

167. Freddy, D. J.; W. M. Bronaugh; and M. C. Fowler. RESPONSES OF MULE DEER TO DISTURBANCE BY PERSONS AFOOT AND SNOWMOBILES. Wildl. Soc. Bull.; 14:63-68. 1986.

The objectives of this study in north-central Colorado were to compare overt behavioral responses of adult female mule deer reacting to persons afoot or snowmobiles during controlled disturbance trials and to monitor their survival and fecundity. The tendency for flight distances to increase when deer exhibited multiple flight responses to persons afoot suggested that deer did not readily habituate to disturbance and these responses were longer in duration, involved running more frequently, and were greater in estimated energy expenditure. Minimizing all responses by deer would require persons afoot and snowmobiles to remain >334 m and > 470 m from deer, respectively. The authors concluded that their disturbance study did not markedly affect the mortality or fecundity of adult female deer.

168. French, J. M.; and J. R. Koplin. DISTRIBUTION, ABUNDANCE, AND BREEDING STATUS OF OSPREYS IN NORTHWESTERN CALIFORNIA. Pages 223-240 in: J. C. Ogden, ed. Trans. of the N. Am. Osprey Res. Conf.; 10-12 February 1972, Williamsburg, VA. U.S. Natl. Park Serv. Trans. Proc. Ser. 2. 1972.
Data are presented concerning abundance and reproduction of ospreys in California. Factors influencing fledgling productivity are discussed, including human disturbance. Logging and shooting were found to seriously affect nesting ospreys, but there was no indication that recreational activities including sightseeing, camping, fishing, and swimming were detrimental to breeding success of ospreys (Boyle and Samson 1983).

169. Fyfe, R. THE PEREGRINE FALCON IN NORTHERN CANADA. Pages 101-114 in: J. J. Hickey, ed. Peregrine falcon populations: their biology and decline. Univ. of Wisconsin Press, Madison. 1969.
Recent evidence suggests that the peregrine remains a common breeding bird in northern Canada, although a local decline was attributed to human disturbance. Human interference with peregrines near northern settlements is a possible deciminating factor.

170. Gabrielsen, G. W. and E. N. Smith. PHYSIOLOGICAL RESPONSES OF WILDLIFE TO DISTURBANCE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 95-107. Island Press, Washington, D.C. 1995.
Note: new.

171. Garber, D. P. OSPREY NESTING ECOLOGY IN LASSEN AND PLUMAS COUNTIES, CALIFORNIA. M.S. thesis; Humboldt State Univ., Arcata. CA. 59 pp. 1972.
Nesting efforts of ospreys were studied in northwestern California. Major cases of nesting failure was high winds and eggshell breakage, but human disturbance was responsible for 33% of observed egg losses. In one case, campers caused adult osprey to abandon a nest with eggs. During fledgling counts young ospreys sometimes flew from nests, apparently for the first time. Such early flights may increase the incidence of injury and predation of fledglings (Boyle and Samson 1983).

172. Garrott, R. A., G. White, R. M. Bartman, L. H. Carpenter, and A. W. Alldredge. MOVEMENTS OF FEMALE MULE DEER IN NORTHWEST COLORADO. Journal of Wildl. Mgmt. 51(3). 1987.
Note: new.
Migration was strongly correlated to winter severity. Demonstrated strong fidelity to summer and winter ranges. Fidelity of individual movement patterns is long term, possibly for life.

173. Garton, E. O.; C. W. Bowen; and T. C. Foin, Jr. THE IMPACT OF VISITORS ON SMALL MAMMAL COMMUNITIES OF YOSEMITE NATIONAL PARK. Pages 44-50 in: T. C. Foin, Jr. ed. Visitor impacts on National Parks: The Yosemite ecological impact study. Univ. California, Davis, Inst. Ecol. Pupl. 10. 1977.
Visitor use of meadow and forest sites in Yosemite National Park was related to the distribution and abundance of small mammals. Deer mouse populations apparently increase in response to human use of forested areas, while mountain vole populations showed no relationship to human use except for gross habitat alterations such as meadow draining. Data for other small mammals were insufficient to determine relationships with human use (Boyle and Samson 1983).

174. Gasoway, W. C.; R. O. Peterson; J. L. Davis; P. E. K. Shepard; and O. E. Burns. *INTERRELATIONSHIPS OF WOLVES, PREY, AND MAN IN INTERIOR ALASKA. Wildl. Monogr. No. 84. 50 pp. 1983.

175. Gavrin, V. F. EFFECT OF ANXIETY FACTOR ON GAME FOWL PRODUCTIVITY. Pages 401-403 in: I. Kjerner and P. Bjurholm, eds. Proc. XIth Int. Cong. of Game Biologists, 3-7 September 1973, Stockholm, Sweden. National Swedish Environmental Protection Board, Stockholm. 1974.
Effects of stress on waterfowl and grouse was studied in the USSR. Recreational activities in bird habitats disturb daily activity patterns and alter the behavior of birds. Disturbance causes additional predation pressures and losses of young to starvation; disrupted timing of breeding lowers female fertility and increases the number of inferior birds in the population (Boyle and Samson 1983).

176. Geist, V. A BEHAVIORAL APPROACH TO THE MANAGEMENT OF WILD UNGULATES. Pages 413-424 in: E. Duffy and A. S. Watts, eds. The scientific management of animal and plant communities for conservation. Symp. British Ecol. Soc. 11. Blackwell Sci. Publ., Oxford. 1971.

177. Geist, V. BEHAVIOR. In: Big Game of North America: Ecology and Management, J. L. Schmidt and D. C. Gilbert, eds., pp 283-296. Stackpole Books. Harrisburg, Penn. 494 pp. 1978.
Note: new.

178. Geist, V. BIGHORN SHEEP ECOLOGY. Wildl. Soc. News; 136:61. 1971.
In a letter to the editor, the author explains physiological and energetic concerns related to increased activity of bighorn sheep following removal of old rams from populations. Harassment of sheep and other animals by a combination of hunting and hiking/wildlife viewing may be fatal to sheep (Boyle and Samson 1983).

179. Geist, V. HARRASSMENT OF LARGE MAMMALS AND BIRDS: WITH A CRITIQUE OF THE RESEARCH SUBMITTED BY ARCTIC GAS STUDY LTD. ON THIS SUBJECT. Report to the Berger Commission 64pp. 1975.

180. Geist, V. IS BIG GAME HARASSMENT HARMFUL? Oilweek; 22(17):12-13. 1971.
Harassment of North American big game is considered in terms of animal energy budgets and physical damage. Energy “costs” of harassment are calculated as energy expended above and beyond normal daily expenditures. Chronic harassment may result in reduced reproductive rates and increased mortality (Boyle and Samson 1983).

181. Geist, V. ON THE BEHAVIOR OF THE NORTH AMERICAN MOOSE IN BRITISH COLUMBIA. Behavior; 20:377-416. 1963.
Calf and yearling moose are sometimes quite tame when adults are absent. The sight of man at close range causes most animals to run; however, there is considerable variation among individual moose. Cites case where moose did not take flight even when one of the group was shot. Intense feeding often occurs after disturbance has passed (Ream 1980).

182. Genter, D. l. *STATUS OF THE SPOTTED BAT (EUDERMA MACULATUM) IN THE PRYOR MOUNTAINS OF SOUTHCENTRAL MONTANA. Report to USDA, U.S. For. Serv., Custer National Forest, Billings. 17 pp. 1988.

183. Genter, D. L.; and L. H. Metzgar. *SURVEY OF THE BAT SPECIES AND THEIR HABITAT USE IN GRAND TETON NATIONAL PARK. Page 65-69 in: Wyoming-National Park Service Research Center, 9th Annual Report. 1985.

184. Gentor, D. L. *WINTERING BATS OF THE UPPER SNAKE RIVER PLAIN: OCCURENCE IN LAVA TUBE CAVES. Great Plains Nat.; 46:241-244. 1986.

185. George, J. L.; C. E. Braun; R. A. Ryder and E. Decker. RESPONSE OF WATERBIRDS TO EXPERIMENTAL DISTURBANCES. Proc. Issues Technol. Manage. Wildl. (Thorne Ecol. Inst.); No. 5, pp. 52-59. 1991.

186. Gerrard, J. M.; and G. R. Bortolotti. *THE BALD EAGLE: HAUNTS AND HABITS OF A WILDERNESS MONARCH. Smithsonian Institution Press, Washington, D.C. 177 pp. 1988.

187. Gese, E. M.; O. J. Rongstad; and W. R. Mytton. CHANGES IN COYOTE MOVEMENTS DUE TO MILITARY ACTIVITY. J. Wildl. Manage.; 53(2):334-339. 1989.
The authors investigated the response of coyotes to military activity on the Pinon Canyon Maneuver Site, Colorado, during 1984-86. Sixteen coyotes responded to military activity by expanding, contracting, abandoning, or not changing their home range during military maneuvers compared to before and after maneuvers. Three coyote abandoned their home ranges, with 1 animal returning to its original home range 1 week after maneuvers. Most coyotes that expanded their ranges during military maneuvers resumed their original home range after military maneuvers ceased. Responses appeared to be related to the amount of available cover, topography, and intensity of military activity in a coyote’s home range. Coyote activity patterns during the day increased, while activity at sunrise, sunset, and night remained the same during military activity.

188. Gilpin, M. E. SPATIAL STRUCTURE AND POPULATION VIABILITY. In: Viable Populations for Conservation, M. E. Soule, ed., pp. 124-139. Cambridge University Press. 1987.
Note: new.

189. Gipson, P. S. ABORTION AND CONSUMPTION OF FETUSES BY COYOTES FOLLOWING ABNORMAL STRESS. Southwestern Naturalist 21:558-559. 1970.
Note: new.

190. Glinski, R. L. BIRDWATCHING ETIQUTTE: THE NEED FOR A DEVELOPING PHILOSOPY. Am. Bird; 30:655-657. 1976.
Examples of disturbance to nongame birds by bird watchers are used to indicate a need to manage bird watching. Disturbance can cause lowered survival and reproduction of birds due to increased energy expenditures, behavior alteration, abandonment of nests, or loss of eggs and young to chilling, overheating, or predation. A behavioral code for bird watchers is proposed to regulate personal activities (Boyle and Samson 1983).

191. Goldsmith, F. B. ECOLOGICAL EFFECTS OF VISITORS IN THE COUNTRYSIDE. Pages 217-231 in: A. Warren and F. B. Goldsmith, eds. Conservation in practice. Wiley and Sons, London. 1974.
Ecological effects of recreation are reviewed, including impacts on wildlife. Sections discuss carrying capacity, characteristics of ecosystems, succession, visitor distribution, effects of trampling, direct research on ecological effects of recreation, and management (Boyle and Samson 1983).

192. Gooders, J. WILDLIFE AND TOURISM. Birds Int.; 1:21-23, 27. 1975.
Wildlife tourism is described as a modern and expanding business. Direct and indirect benefits of tourism to wildlife conservation are contrasted with impacts including disturbance to wildlife. The author suggests that tourism will continue to expand, and that steps should be taken to minimize disturbances to wildlife (Boyle and Samson 1983).

193. Goodrich, J. M.; and J. Berger. WINTER RECREATION AND HIBERNATING BLACK BEARS URSUS AMERICANUS. Biol. Conserv.; 67(2): 105-110. 1994.

194. Goodson, N. J. STATUS OF BIGHORN SHEEP IN ROCKY MOUNTAIN NATIONAL PARK. M.S. thesis; Colorado State Univ., Fort Collins. 190 pp. 1978.
During studies of bighorn sheep in Rocky Mountain National Park, Colorado, sheep interactions with people were noted. In areas where sheep were accustomed to seeing people, they tolerated people if approached gradually and not too closely; however, on several occasions sheep were driven from feeding areas or mineral licks by visitors. Sheep in backcountry areas were more wary (Boyle and Samson 1983).

195. Graefe, A. R., F. R. Kruss, and J. J. Vaske. VISITOR IMPACT MANAGEMENT: THE PLANNING FRAMEWORK. National Parks and Conservation Association. Washington, D.C. 105 pp. 1990.
Note: new.

196. Graefe, A. R., F. R. Krass, and J. J. Vaske. VISITOR IMPACT MANAGEMENT. Vols. I and II. National Parks and Conservation Association. Washington, D.C. 1990.
Note: new.

197. Graham, H. ENVIRONMENTAL ANALYSIS PROCEDURES FOR BIGHORN IN THE SAN GABRIEL MOUNTAINS. Trans. Desert Bighorn Counc.; 15:38-45. 1971.
Graphic analysis was used to evaluate bighorn habitat in California. Human use impacts were portrayed on overlays and compared to bighorn distributions and other habitat characteristics. Human recreational use has caused sheep to avoid certain areas. Light use has little effect on sheep distributions, but heavier use (500-900 visitor-days per summer season) causes bighorns to move from their historic range (Boyle and Samson 1983).

198. Graham, H. THE IMPACT OF MODERN MAN. Pages 288-309 in: G. Monson and L. Sumner, eds. The desert bighorn: Its life history, ecology, and management. Univ. of Arizona Press, Tucson. 1980.
The history of man’s relationship with bighorn sheep and current impacts of man on sheep are reviewed. Effects of hiking, horseback riding, motor vehicles, motorboats, ski lifts and tramways, aircraft, noises, and dogs are discussed. Human-caused habitat alterations are related to tolerance of sheep to intrusions (Boyle and Samson 1983).

199. Graham, H. MULTIPLE USE COORDINATION ON THE SAN GORGONIO BIGHORN UNIT. Trans. Desert Bighorn Counc.; 10:71-77. 1966.
Multiple use management of a California national forest area containing bighorn sheep is discussed. The authors explains the rationale and methodology of multiple use, and describes various land uses and their coordination with bighorn management. Proposals for massive recreational developments have been rejected because of perceived incompatibility with preservation of key bighorn habitats (Boyle and Samson 1983).

200. Graul, W. D. *ADAPTIVE ASPECTS OF THE MOUNTAIN PLOVER SOCIAL SYSTEM. Living Bird; 12:69-94. 1973.
201. Graul, W. D. *BREEDING BIOLOGY OF THE MOUNTAIN PLOVER. Wilson Bull.; 87:6-31. 1975.
202. Graul, W. D. and G. C. Miller. STRENGTHENING ECOSYSTEM MANAGEMENT APPROACHES. Wildl. Soc. Bull. 12:282-289. 1984.
Note: new.
203. Graul, W. D.; and L. E. Webster. *BREEDING STATUS OF THE MOUNTAIN PLOVER. Condor; 78:265-267. 1976.
204. Gray, J. R. KINDS AND COSTS OF RECREATIONAL POLLUTION IN THE SANDIA MOUNTAINS. New Mexico State Univ., Las Cruces, Agric. Exp. Sta. Bull. 651. 57 pp. 1977.
Environmental costs of recreation in the Sandia Mountains, New Mexico, were quantified by surveying recreationists, identifying associated pollutants and environmental impacts, and calculating costs of their control. Wildlife harassment, primary by hikers, was among impacts that tended to restrict activities most in a cost analysis model. Nature study and hunter groups were determined as having the highest cost per hour (Boyle and Samson 1983).
205. Gray, J. A. PSYCHOLOGY OF FEAR AND STRESS, 2ND ED. Cambridge University Press. New York. 1987.
Note: new.
206. Greater Yellowstone Coordinating Committee. AN AGGREGATION OF NATIONAL PARK AND NATIONAL FOREST MANAGEMENT PLANS. A cooperative project of the NPS and NFS. 1987.
207. Greater Yellowstone Bald Eagle Working Team. A BALD EAGLE MANAGEMENT PLAN FOR THE GREATER YELLOWSTONE ECOSYSTEM. Wyoming Game and Fish Dept., Cheyenne. 82 pp. 1983.
208. Greater Yellowstone Bald Eagle Working Team. SIX-YEAR SUMMARY PRODUCTION REPORT FOR THE GREATER YELLOWSTONE ECOSYSTEM. Compiled and edited by Bob Jones and Russ McFarling, U.S. Bur. Land Manage., Idaho Falls, ID. 1989.
209. Greer, T. ENVIRONMENTAL IMPACT OF SNOWMOBILES: A REVIEW OF THE LITERATURE. Univ. of Oregon, Portland. 1979.
Note: new.
210. Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. AN ECOSYSTEM PERSPECTIVE OF RIPARIAN ZONES. BioScience 41:540-551. 1991.
Note: new.
211. Greller, A. M., et al. SNOWMOBILE IMPACT ON THREE ALPINE TUNDRA PLANT COMMUNITIES. Environmental Conservation 1(2):101-110. 1974.
Note: new.
212. Grier, J. W.; J. B. Elder; F. J. Gramlich; N. F. Green; J. V. Kussman; J. E. Mathisen; and J. P. Mattsson. NORTHERN STATES BALD EAGLE RECOVERY PLAN. USDI; Fish and Wildlife Service. 1983.

213. Groves, C. R. *DISTRIBUTION OF THE WOLVERINE IN IDAHO AS DETERMINED BY MAIL QUESTIONNAIRE. Northw. Sci.; 62(4):181-185. 1988.

214. Grubb, T. G.; and R. M. King. ASSESSING HUMAN DISTURBANCE OF BREEDING BALD EAGLES WITH CLASSIFICATION TREE MODELS. J. Wildl. Manage.; 55(3):500-511. 1991.
The researchers recorded 4,188 events of human activity and associated bald eagle response in the vicinity of 13 central Arizona nest sites during 1983-1985. A hierarchical classification of 9 dependent parameters and 3 independent parameters was developed to quantify pedestrian, aquatic, vehicle, noise (gunshot/sonic boom), and aircraft disturbance groups. Type and frequency of response varied inversely with the distance from an eagle to the disturbance. Bald eagles were more often flushed from perches than nests and were most easily disturbed when foraging. Pedestrian was the most disturbing human activity, whereas aircraft was the least. A classification tree (CART) model was developed for pooled and group disturbances to evaluate response severity and to formulate disturbance-specific management criteria. The CART models ranked distance to disturbance as the most important classifier of eagle response, followed in decreasing order of discriminatory value by duration of disturbance, visibility, number of units per event, position relative to affected eagle, and sound. This procedure offers improved specificity in human disturbance assessment.

215. Grubb, T. G.; W. W. Bowereman; J. P. Geisy; and G. A. Dawson. REPONSES OF BREEDING BALD EAGLES, HALIAEETUS LEUCOCEPHALIS, TO HUMAN ACTIVITIES IN NORTHCENTRAL MICHIGAN. Canadian Field-Nat.; 106(4):443-453. 1992.
The authors recorded 714 events of potentially disturbing human activity near six pairs of Bald Eagles breeding in northcental Michigan in 1990. Vehicles and pedestrians elicited the highest response frequencies, but aircraft and aquatic activities were the most common. Magnitude of response was inversely proportional to median distance-to-disturbance. Seventy-five percent of all alert and flight responses occurred when activity was within 500m and 200m, respectively. Adults responded more frequently than nestlings, and at greater distance-to-disturbance when perched away from nests. May was the peak month for human activity, most of which occurred on weekends (60%) and afternoon (72%). Classification tree (CART) models are used to assess disturbance-specific response frequencies and to formulate management considerations.

216. Guth, R. W. FOREST AND CAMPGROUND BIRD COMMUNITIES OF PENINSULA STATE PARK, WISCONSIN. Passenger Pigeon; 40:489-493. 1978.
A study in Door County, Wisconsin, compared bird populations of mature forests, forest edge, and altered campground sites. Bird density and species diversity were least in forest sites, and greatest in campgrounds. Birds in campgrounds represented a greater percentage of common and widespread species, whereas several rare forest species were absent (Boyle and Samson 1983).

217. Guth, R. W. THE JUNK FOOD GUILD: BIRDS AND MAMMALS ON PICNIC GROUNDS AND IN RESIDENTIAL AREAS. Ill. Audubon Bull.; 189:3-7. 1979.
Birds and mammals of the junk food guild benefit from human recreation by finding scraps of food in picnic grounds of parks and forest preserves. Experiments in urban areas near Chicago, Illinois, revealed aspects of foraging behavior and food selection by residential area birds (Boyle and Samson 1983).

218. Gutzwiller, K. J. ASSESSING RECREATIONAL IMPACTS ON WILDLIFE: THE VALUE AND DESIGN OF EXPERIMENTS. Trans. N. Am. Wildl. Nat. Res. Conf.; 56:248-255. 1991.

219. Gutzwiller, K. J. RECREATIONAL DISTURBANCE AND WILDLIFE COMMUNITIES. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 169-181. Island Press, Washington, D.C. 1995.
Note: new.

220. Gutzwiller, K. J. RECREATIONAL DISTURBANCE AND WILDLIFE COMMUNITIES. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 169-181. Island Press. Washington, D.C. 1995.
Note: new.

221. Gutzwiller, K. J. SERIAL MANAGEMENT EXPERIMENTS: AN ADAPTIVE APPROACH TO REDUCE RECREATIONAL IMPACTS ON WILDLIFE. Trans. N. Am. Wildl. and Nat. Resour. Conf.; 58:528-536. 1993.

222. Haber, G. C. EIGHT YEARS OF WOLF RESEARCH AT MCKINLEY PARK. Alaska; 39(4):43-45, 59, 53-56. 1973.
These popular articles summarize research results and observations concerning wolves in Mount McKinley National Park, Alaska. Wolf social systems, behavior, and relationships to prey species and humans are discussed.

223. Hagen, A. and A. Langeland. POLLUTED SNOW IN SOUTHERN NORWAY AND THE EFFECT OF THE MELTWATER ON FRESHWATER AND AQUATIC ORGANISMS. Environ. Pollution 5:45-57. 1973.
Note: new.

224. Haines, H. E. J. SNOWMOBILES IN YELLOWSTONE: BIOMASS ALTERNATIVES TO REDUCE POLLUTION. Montana Dept. of Environmental Quality. Survey of Visitor Impact on Wildlife. Curtis Canyon Area, National Elk Refuge, Jackson, Wyo. 1984.
Note: new.

225. Hammitt, W. E. and D. N. Cole. WILDLAND RECREATION: ECOLOGY AND MANAGEMENT. John Wiley and Sons. New York.
Note: new.

226. Hammitt, W. E.; J. N. Dulin; and G. R. Wells. DETERMINANTS OF QUALITY WILDLIFE VIEWING IN GREAT SMOKY MOUNTAINS NATIONAL PARK. Wildl. Soc. Bull.; 21:21-30. 1993.
Factors affecting the quality of wildlife viewing for 384 visitors to Cades Cove, Great Smoky Mountains National Park, were surveyed. Wildlife visibility potential, visual encounters with wildlife, visitor expectation and preference standard toward visual encounters, importance of type and number of animals seen, and viewer behavior were regressed on quality of wildlife viewing during an 18 km auto tour. Respondents rated quality of viewing high, with most visitors seeing 5 or more types of wildlife, and nearly everyone seeing white-tailed deer. Expectations toward the variety and total numbers of animals seen, preference standards toward seeing black bears, and the viewing behaviors of stopping the car and using binoculars to enhance viewing were the best predictors of a quality wildlife viewing experience.

227. Hanley, S. E. WILDLIFE MANAGEMENT IN YELLOWSTONE NATIONAL PARK, 1962-1976. M.S. thesis; Univ. Wyo., Laramie. 130 pp. 1992.
228. Hare, C. T. and K. J. Springer. SNOWMOBILE ENGINE EMISSIONS AND THEIR IMPACT. Office of Air and Water Programs, Environmental Protection Agency, Southwest Research Institute. San Antonio, Tex. 1974.
Note: new.
229. Harrington, F. H.; and L. D. Mech. *WOLF HOWLING AND ITS ROLE IN TERRITORIAL MAINTENANCE. Behavior; 69(3-4):207-248. 1978.
230. Harris, L. D. and P. B. Gallagher. NEW INITIATIVES FOR WILDLIFE CONSERVATION: THE NEED FOR MOVEMENT CORRIDORS. In: Conservation Biology: The Theory and Practice of Nature Conservation, Preservation, and Management, P. L. Fiedler and S. K. Jain, eds., pp. 197-237. Chapman and Hall. New York. 1989.
Note: new.
231. Harrison, R. T. PREDICTING SNOWMOBILE ACOUSTIC IMPACT ON RECREATIONISTS. U.S. For. Ser. Equp. Dev. Center, ED&T Project No. 9227. San Dimas, Calif. 1980.
Note: new.
232. Hartmata, A. R. BALD EAGLE MOVEMENT AND HABITAT USE COMPLETION REPORT. Pages 10-39 in: B. Oakleaf, D. Belitsky, and S. Ritter, eds. Endangered and nongame bird and animal investigations. Ann. Completion Report. Period covered: April 15, 1986 to April 14, 1987. Wyoming Game and Fish Dept., Cheyenne. 189 pp. 1987.
233. Hartmata, A. R. *A COMPREHENSIVE ECOLOGICAL STUDY OF BALD EAGLES IN THE GREATER YELLOWSTONE ECOSYSTEM. Wyoming Game and Fish Dept., Cheyenne.
234. Hartmata, A. R. GREATER YELLOWSTONE BALD EAGLE MANAGEMENT PLAN. Greater Yellowstone Bald Eagle Working Group, Wyo. Game and Fish Dept., Lander, Wyo. 47 pp. 1996.
Note: new.
235. Hash, H. S. *WOLVERINE. Pages 574-585 in: M. Novak, J. Baker, M. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario. 1987.
236. Haug, E. A. *OBSERVATIONS ON THE BREEDING ECOLOGY OF THE BURROWING OWLS IN SASKATCHEWAN. M.S. thesis; University of Saskatchewan, Saskatoon. 1985.
237. Hayward, G. D. *HABITAT USE AND POPULATION BIOLOGY OF BOREAL OWLS IN THE NORTHERN ROCKY MOUNTAINS, U.S.A. Ph.D. Diss. University of Idaho, Moscow. 113 pp. 1989.
238. Hayward, G. D.; P. H. Hayward; and E. O. Garton. *HABITAT USE AND DISTRIBUTION OF THE BOREAL OWL IN CENTRAL IDAHO: ANNUAL PROGRESS REPORT. Dept. of Fish and Wildlife Resources, College of Forestry, Wildlife, and Range Sciences, Univ. Idaho, Moscow. 10 pp. 1987.

239. Hayward, G. D.; P. H. Hayward; and E. O. Garton. *MOVEMENTS AND HOME RANGE USE BY BOREAL OWLS IN CENTRAL IDAHO. In: R. W. Nero, C. R. Knapton, and R. J. Hamre, eds. Biology and conservation of northern forest owls: symposium proceedings. USDA, U.S. For. Serv. Gen, Tech Rep. RM-142, Rocky Mountain Forest and Range Exp. Sta., Fort Collins. 309 pp. 1987.
240. Hayward, G. D.; P. H. Hayward, E. O. Gaton; and R. Escano. *REVISED BREEDING DISTRIBUTION OF THE BOREAL OWL IN THE NORTHERN ROCKY MOUNTAINS. Condor; 89:431-432. 1987.
241. Heinrich, B.; B. Oakleaf; D. Flath; and W. Melquist. *A COOPERATIVE PROPOSAL FOR REINTRODUCTION OF PEREGRINE FALCONS IN ADJACENT AREAS OF IDAHO, MONTANA, AND WYOMING. Unpub. proposal. 19 pp. 1985.
242. Hendee, J. C., G. H. Stankey, and R. C. Lucas. WILDERNESS MANAGEMENT. Misc. Publ. No. 1365. USFS, Dept. of Agric. 38 pp. 1978.
Note: new.
243. Hendee, J. C.; and D. R. Potter. HUMAN BEHAVIOR AND WILDLIFE MANAGEMENT: NEEDED RESEARCH. Trans. N. Am. Wildl. Nat. Resourc. Conf.; 36:383-396. 1971.
Broad problem areas and specific questions about human behavior aspects of wildlife management are identified. Research should be directed toward various aspects of hunter behavior, nonconsumptive uses of wildlife, wildlife economics, and political-legal issues. As nonconsumptive use of wildlife increases, managers are challenged to both gain support from and supply satisfaction to appreciative users (Boyle and Samson 1983).
244. Henry, J. YELLOWSTONE WINTER GUIDE. Roberts Rinehart Publ., Niwot, CO. 95 pp. 1993.
245. Henry, W. RELATIONSHIPS BETWEEN VISITOR USE AND CAPACITY FOR KENYA'S AMBOSELI NATIONAL PARK. Ph.D. Dissertation. Fort Collins, Colorado: Colorado State University. 1980.
Note: new.
246. Hensen, P.; and T. A. Grant. *THE EFFECTS OF HUMAN DISTURBANCE ON TRUMPETER SWAN BREEDING BEHAVIOR. Wildl. Soc. Bull.; 19:248-257. 1991.
247. Hickey, J. J. *PEREGRINE FALCON POPULATIONS: THEIR BIOLOGY AND DECLINE. University of Wisconsin Press, Madison. 596 pp. 1969.
248. Hicks, L. L.; and J. M. Elder. HUMAN DISTURBANCE OF SIERRA NEVADA BIGHORN SHEEP. J. Wildl. Manage.; 43(4):909-915. 1979.
Direct observations, pellet transects, and hiker interviews were used to assess use overlap and nature of interactions between humans and bighorn sheep in California. Distance, juxtaposition, and herd size and composition were important factors in reaction of sheep to humans. Bighorn-human encounters were not adversely affecting the bighorn population; nevertheless, limitation of human use of the study area is recommended (Boyle and Samson 1983).
249. Hoak, J. H.; J. L. Weaver; and T. W. Clark. *WOLVERINES IN NORTHWESTERN WYOMING. Northw. Sci.; 56:156-161. 1982.

250. Hoffman, R. S. *NOTES ON SOREX IN THE NORTHERN ROCKY MOUNTAIN ALPINE ZONE. J. Mammal.; 41:230-234. 1960.
251. Hoffmann, R. S.; and J. G. Owen. *SOREX TENELLUS AND SOREX NANAUS. Mammalian species No. 131:1-4. 1980.
252. Hoffmann, R. S.; P. L. Wright; and F. E. Newby. *THE DISTRIBUTION OF SOME MAMMALS IN MONTANA. J. Mammal.; 50:579-604. 1969.
253. Hofmann, R. S.; and R. D. Fisher. *ADDITIONAL DISTRIBUTIONAL RECORDS OF PREBLES SHREW. J. Mammal.; 59:883-884. 1978.
254. Holmes, T. L.; R. L. Knight; L. Stegall; and G. R. Craig. RESPONSES OF WINTERING GRASSLAND RAPTORS TO HUMAN DISTRUBANCE. Wildl. Soc. Bull.; 21:461-468. 1993.
The authors measured the flushing responses and flushing distances of 6 species of diurnal raptors (American kestrels, merlins, prairie falcons, rough-legged hawks, ferruginous hawks, and golden eagles) exposed to walking and vehicle disturbances during winter in northern Colorado. Walking disturbances resulted in more flushes than vehicle disturbances for all species except prairie falcons. Although flush distance did not vary with disturbance type for the three falcon species, rough-legged hawks and golden eagles flushed at greater distances for walking disturbances and ferruginous hawks flushed at greater distances for vehicle disturbances. Merlins and prairie falcons perched along paved roads had shorter flush distances to walking disturbances than individuals perched along gravel roads. Rough-legged hawks perched nearer to the road flushed at greater distances than those farther away. American kestral, prairie falcons, and ferruginous hawks perched closer to the ground had greater flush distances than those perched higher. Dark-morph ferruginous and rough-legged hawks flushed at greater distances than light morphs. For walking disturbances, a linear relationship existed between flight distance and body mass, with lighter species flushing at shorter distances; however, this trend did not hold for vehicle disturbances.
255. Holyrod, J. C. OBSERVATIONS OF ROCKY MOUNTAIN GOATS ON MOUNT WARDLE, KOOENAY NATIONAL PARK, BRITISH COLUMBIA. Can. Field-Nat.; 81:1-22. 1967.
Behavior of mountain goats in British Columbia is described, including reactions to man. Goat responses to human presence varied according to season, herd size, and other circumstances. Goats were rarely aggressive toward the author, although two incidents are described in which a goat appeared to threaten him (Boyle and Samson 1983).
256. Hooper, R. G. NESTING HABITS OF COMMON RAVENS IN VIRGINA. Wilson Bull.; 89:233-242. 1977.
In a study of raven nesting habitats in Virginia, relationships of nesting ravens in response to human pressure was variable depending on the situation. Human activity should be restricted near active nests, despite the observed tenacity of some nesting pairs. Most birds would not be affected by recreation activity farther than 200 meters from nests (Boyle and Samson 1983).
257. Hoover, R. L.; and D. L. Wills, eds. *MANAGING FORESTED LANDS FOR WILDLIFE. Colorado Division of Wildlife in cooperation with USDA Forest Service, Rocky Mountain Region, Denver, CO. 459 pp. 1984.

258. Horejsi, B. SOME THOUGHTS AND OBSERVATIONS ON HARASSMENT OF BIGHORN SHEEP. Pages 149-155 in: Proc. of the Biennial Symposium of the Northern Bighorn Sheep Council, 10-12 February 1976, Jackson, WY. 1976.
Harassment and its possible effects on bighorn sheep are discussed. Active harassment results in visible responses by sheep, while passive harassment produces no visible response but may have psychological and physiological effects on sheep. Harassment has significant impacts on individuals and populations, leading to a variety of conditions which reduce fitness. Minimizing harassment of sheep should be given top priority among management objectives (Boyle and Samson 1983).
259. Horney, R. L. SNOWMOBILING: GUIDELINES, ENVIRONMENTAL IMPACT, LEGISLATION, PROGRAMMING. National Recreation and Park Association. Washington, D.C. 1970.
Note: new.
260. Hornocker, M. G. *AN ANALYSIS OF MOUNTAIN LION PREDATION UPON MULE DEER AND ELK IN THE IDAHO PRIMITIVE AREA. Wildl. Monogr. 21:1-39. 1970.
261. Hornocker, M. G. WINTER TERRITORIALITY IN MOUNTAIN LIONS. J. Wildl. Manage.: 33:457-464. 1969.
262. Hornocker, M. G.; and H. S. Hash. *ECOLOGY OF THE WOLVERINE IN NORTHWESTERN MONTANA. Can. J. Zool.; 59:1286-1301. 1981.
263. Houston, D. B. ECOSYSTEMS OF NATIONAL PARKS. Science; 172:648-651. 1971.
Management of U.S. National Parks is aimed at preserving park ecosystems in as pristine a condition as possible, and primarily involves preventing or compensating for human influences. So-called nonconsumptive uses such as sightseeing may in fact alter energy and geothermal pathways, disturbing park vegetation and wildlife. Managers must realize that these areas have a finite capacity for absorbing human disturbances (Boyle and Samson 1983).
264. Houston, J. DOGS VS. DEER. Colo. Outdoors; 17(1):22-23. 1968.
265. Hoyt, S. F. *THE ECOLOGY OF THE PILEATED WOODPECKER. Ecology; 38:246-256. 1957.
266. Hudson, R. J. and R. J. Christopherson. MAINTENANCE METABOLISM. In: Bioenergetics of Wild Herbivores, R. J. Hudson and R. G. White, eds. CRC Press, Boca Raton, Fla. 314 pp. 1986.
Note: new.
267. Huff, D. E.; and P. J. Savage. A CORRELATION OF DEER MOVEMENTS WITH SNOWMOBILE ACTIVITY IN MINNESOTA DURING WINTER. Proc. Midwest Fish Wildl. Conf.; 34:42-49. 1972.
Studies of telemetered white-tailed deer in Minnesota compared deer activities between areas of high and no snowmobile use. The size of deer home ranges was much reduced at the high use area, and snowmobile use appeared to force deer into less preferred habitats where nighttime radiant heat loss was greater (Boyle and Samson 1983).
268. Interagency Grizzly Bear Committee. *GRIZZLY BEAR COMPENDIUM. Interagency Grizzly Bear Committee, Missoula. 540 pp. 1987.

269. Interagency Grizzly Bear Committee. *INTERAGENCY GRIZZLY BEAR GUIDELINES. Interagency Grizzly Bear Committee, Missoula. 100 pp. 1986.

270. Irwin, L. and J. Peek. RELATIONSHIP BETWEEN ROAD CLOSURES AND ELK BEHAVIOR IN NORTHERN IDAHO. University of Idaho and USDA Forest Service, Technical Report. 1979.
Note: new.

271. Isakovic, I. EFFECTS OF LAND USE AND OUTDOOR RECREATION ON GAME POPULATIONS. Pages 351-356 in: I. Kjerner and P. Bjurholm, eds. Proc. XIth Int. Cong. of Game Biologists, 3-7 September 1973, Stockholm. 1974.
An overview of man's effect on game populations through land use and recreation is provided. Recreationists fleeing from polluted urban environments make demands on nature that must be harmonized with the capacity of the land to absorb them. Plans to control impacts of tourism must be worked out, especially in areas where it is no longer possible to reserve large areas of land for protection (Boyle and Samson 1983).

272. Ittner, R. D., D. R. Potter, J. K. Agee, and S. Anschell, eds. Conf. Proceedings: RECREATIONAL IMPACTS ON WILDLANDS. U.S. For. Serv. and U.S. Natl. Park Serv., R-6-001. Seattle, Wash. 341 pp. 1979.
Note: new.

273. Jacobsen, N. K. ALARM BRADYCARDIA IN WHITE-TAILED DEER FAWNS. Jour. of Mammalogy 60:343-349. 1979.
Note: new.
The near approach of humans will cause newborn fawns to drop to the ground. After 2 weeks old, the same stimulus will cause them to run.

274. Janssen, R. NOISE AND ANIMALS: PERSPECTIVES OF GOVERNMENT AND PUBLIC POLICY. Pages 287-301 in: J. L. Fletcher and R. G. Busnel, eds. Effects of noise on wildlife. Academic Press, New York. 1978.
Impacts of human-caused noise on wildlife and domesticated animals must be determined so that proper decisions can be made by policy makers. An animal-response model to quantify the effects of noise on animals is presented. Wildlife exposures to noise are generally involuntary and come from mobile sources such as airplanes and recreational vehicles (Boyle and Samsom 1983).

275. Jarvinen, J. A. and W. D. Schmidt. SNOWMOBILE USE AND WINTER MORTALITY OF SMALL MAMMALS. In: Proceedings of the 1971 Snowmobile and Off the Road Vehicle Research Symposium, M. Chubb, ed., pp. 130-140, Tech. Rep. No. 8, Recreation, Research and Planning Unit, Dept. Park and Recreation Resour. Michigan State Univ., East Lansing. 196 pp. 1971.
Note: new.
Study area: Minnesota. Used traps. Meadow vole, short-tailed shrew, white-footed mouse, ground squirrel, masked shrew and spotted skunk. Study showed increased mortality of small mammals, destroyed subnivean air spaces. Also a possibility of toxic air trapped in snow. Even conservative levels of snowmobiling on trails is destructive to wintering small mammals.

276. Johnsgard, P. A. *THE BIRDS OF THE ROCKY MOUNTAINS. Colorado Associated University Press, Boulder. 504 pp. 1986.

277. Johnsgard, P. A. *NORTH AMERICAN OWLS. Smithsonian Institution Press, Washington, D.C. 295 pp. 1988.
278. Johnsgard, P. A. *THE PLOVERS, SANDPIPERS, AND SNIPES OF THE WORLD. University of Nebraska Press, Lincoln. 493 pp. 1981.
279. Johnson, T. H. RESPONSES OF BREEDING PEREGRINE FALCONS TO HUMAN STIMULI. In: Proc. Southwest Raptor Management Symposium and Workshop, Gilinski et al., eds. National Wildlife Federation, Washington, D.C. 1988.
Note: new.
280. Jonkel, C. WINTER DISTURBANCE AND GRIZZLY BEARS. Border Grizzly Proj., Univ. Mont., Missoula, Spec. Rep. No. 46. 1980.
281. Jonkel, C. J.; and I. T. McCowan. *THE BLACK BEAR IN THE SPRUCE-FIR FOREST. Wildl. Monogr.; 27:1-57. 1971.
282. Jope, K. L. IMPLICATIONS OF GRIZZLY BEAR HABITUATION TO HIKERS. Wildl. Soc. Bull; 13:32-37. 1985.
283. Junge, J. A.; and R. S. Hoffman. *AN ANNOTATED KEY TO THE LONG-TAILED SHREWS OF THE UNITED STATES AND CANADA WITH NOTES ON MIDDLE AMERICAN SOREX. Univ. Kan. Nat. Hist. Occ. Pap.; 94:1-48. 1981.
284. Kaiser, M. S.; and E. K. Fritzell. EFFECTS OF RIVER RECREATIONISTS ON GREEN-BACKED HERON BEHAVIOR. J. Wildl. Manage.; 48(2):561-567. 1984.
The authors studied the effects of river recreationists on green-backed heron behavior in southeastern Missouri. They determined that feeding behavior of green-backed herons was adversely affected by human activity as evidenced by the observed reduction of foraging bouts.
285. Keating, K. A.; L.R. Irby; and W. F. Kasworm. MOUNTAIN SHEEP WINTER FOOD HABITS IN THE UPPER YELLOWSTONE VALLEY. J. Wildl. Manage.; 49(1):156-161. 1985.
286. Keddy, P. A., A. J. Spaovld, and C. J. Keddy. SNOWMOBILE IMPACT ON OLD FIELD AND MARSH VEGETATION IN NOVA SCOTIA, CANADA: AN EXPERIMENTAL STUDY. Environmental Management 3:409-415. 1979.
Note: new.
287. Keith, L. B. *POPULATION DYNAMICS OF WOLVES. Pages 66-77 in: L. N. Carbyn, ed. Wolves in Canada and Alaska: their status, biology, and management. Can. Wildl. Serv. Rep. No, 45, Ottawa. 135 pp. 1981.
288. Keller, S. R. and J. K. Berry. A BIBLIOGRAPHY OF HUMAN/ANIMAL RELATIONS. Univ. Press of America. Lanham, MD. 1985.
Note: new.
289. Kemp, H. TAPPING INTO THE FISH AND WILDLIFE EXPLOSION: COMMERCIAL ON-LINE DATA SOURCES. USDI, U.S. Fish Wildl. Ser. Leaflet 16, Washington, D.C. 1992.
290. King, M. M. and G. W. Workman. RESPONSE OF DESERT BIGHORN SHEEP TO HUMAN HARASSMENT: MANAGEMENT IMPLICATIONS. Transactions of the North American Wildlife and Natural Resources Conference 51:74-85. 1986.
Note: new.

291. Kirby, R. E. IMPACT OF HUMAN ACTIVITY UPON WILDLIFE AND WILDLIFE HABITAT. Statement of Work, Office Info. Transfer, Res. and Develop., U.S. Fish and Wildl. Serv. 3 pp. 1985.
Note: new.
292. Kirkpatrick, C. M., ed. PROCEEDINGS: WILDLIFE AND PEOPLE. Dept. For. Nat. Resour., Purdue Univ., Lafayette, Ind. 191 pp. 1985.
Note: new.
293. Klein, M. L. WATERBIRD BEHAVIORAL RESPONSES TO HUMAN DISTURBANCES. Wildl. Soc. Bull.; 21:31-39. 1993.
The author subjected waterbirds to experimental disturbance at the J. N. "Ding" Darling National Wildlife Refuge, located off the southern gulf coast of Florida, to investigate the effects of human actions on their behavior. Approaching the birds on foot was the most disruptive activities of refuge visitors. Photographers were most likely to engage in this activity. Visitors who spoke with refuge staff early during their visit caused the least disturbance. The author conclude that educational programs, coupled with the use of observation blinds or guided tours, could help reduce bird disturbance.
294. Klein, T. LOON MAGIC. Paper Birch Press, Ashland, WI. 130 pp. 1985.
295. Knight, R. L. and S. K. K. Skagen. EFFECTS OF RECREATIONAL DISTURBANCE ON BIRDS OF PREY: A REVIEW. In: Proceedings of the Southwest Raptor Management Symposium and Workshop, L. Glinski et al., eds., pp. 355-359. National Wildlife Federation, Washington, D.C. 1988.
Note: new.
296. Knight, R. L. and d. N. Cole. FACTORS THAT INFLUENCE WILDLIFE RESPONSES TO RECREATIONISTS. In: Wildlife and Recreationists: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 71-79. 1995.
Note: new.
297. Knight, R. L. RESPONSES OF WINTERING BALD EAGLES TO BOATING ACTIVITY. J. Wildl. Manage.; 48(3):999-1004. 1984.
The author examined flushing responses and flight distances of wintering bald eagles disturbed by a canoe in northwestern Washington. Management implications are discussed.
298. Knight, R. L. and K. J. Gutzwiller, eds. WILDLIFE AND RECREATIONISTS: COEXISTENCE THROUGH MANAGEMENT AND RESEARCH. Island Press. Washington, D.C. 372 pp. 1995.
Note: new.
Physiological and psychological responses, indirect effects, management strategies, case histories, ethics, historical perspectives.
299. Knight, R. L.; and D. N. Cole. EFFECTS OF RECREATIONAL ACTIVITY ON WILDLIFE IN WILDLANDS. Trans. N. Am. Wildl. and Nat. Resour. Conf.; 56:238-247. 1991.
300. Knight, R. L.; and L. L. Eberhardt. *POPULATION DYNAMICS OF YELLOWSTONE GRIZZLY BEARS. Ecology; 66:323-334. 1985.

301. Knight, R. L.; B. M. Blancard; and L. L. Eberhardt. MORTALITY PATTERNS AND POPULATION SINKS FOR YELLOWSTONE GRIZZLY BEARS, 1973-1985. Wildl. Soc. Bull.; 16:121-125. 1988.
This study determined that the extensive movements of grizzly bears and dispersion of population sinks in time in space suggest there are no true refuges for Yellowstone grizzly bears. Increasing human use and recreational activities in the Yellowstone area will increase this problem. For the present, available food for bears at population sinks is the greatest threat to survival of the Yellowstone grizzly population.

302. Knight, R. L.; J. Beecham; B. Blanchard; L. Eberhardt; L. Metzgar; C. Serveen; and F. Talbot. *REPORT OF THE YELLOWSTONE GRIZZLY BEAR POPULATION TASK FORCE. Submitted to the Interagency Grizzly Bear Committee. Unpub. 9 pp. 1988.

303. Knight, S. K. and R. L. Knight. VIGILANCE PATTERNS OF BALD EAGLES FEEDING IN GROUPS. Auk 103:263-272. 1986.
Note: new.

304. Kolenosky, G. B.; and S. M. Strathearn. *BLACK BEAR. Pages 445-454 in: M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Nat. Resources, Ontario. 1987.

305. Kopischke, E. D. EFFECTS OF SNOWMOBILE ACTIVITY ON THE DISTRIBUTION OF WHITE-TAILED DEER IN SOUTH CENTRAL MINNESOTA. Dept. Nat. Res. Game Research Proj. Rept. 1972.
Note: new.

306. Korschgen, C. E.; and R. B. Dahlgren. HUMAN DISTURBANCES OF WATERFOWL: CAUSES, EFFECTS, AND MANAGEMENT. USDI, U.S. Fish Wildl. Ser. Leaflet 13.2.15. 1992.

307. Krausman, P. R.; B. D. Leopold; and D. L. Scarbrough. DESERT MULE DEER RESPONSE TO AIRCRAFT. Wildl. Soc. Bull.; 14:68-70. 1986.
Responses of desert mule deer to aircraft overflights in Arizona rarely involved changing habitat. The authors conclude that the desert mule deer in southcentral Arizona appear to have habituated to low-flying aircraft and that reliable habitat-use information can be obtained from aircraft.

308. Krueger, C. D., J. Decker, and T. A. Gavin. A CONCEPT OF NATURAL RESOURCE MANAGEMENT: AN APPLICATION TO UNICORNS. Trans. Northeast Sect. Wildl. Soc. 43:50-56. 1986.
Note: new.
A simplified, idealized conceptual model for resource management.

309. Krutzsch, P. H. *NOTES ON THE HABITS OF THE BAT MYOTIS CALIFORNICUS. J. Mammal.; 35:539-545. 1954.

310. Kuchel, C. R. SOME ASPECTS OF THE BEHAVIOR AND ECOLOGY OF HARLEQUIN DUCKS BREEDING IN GLACIER NATIONAL PARK. M.S. thesis; University of Montana, Missoula. 163 pp. 1977.

311. Kugler, B. A. and D. S. Barber. A METHOD FOR MEASURING WILDLIFE NOISE EXPOSURE IN THE FIELD (Abstract). Journ. of the Acoustical Society of America 93(4):2378. 1993.
Note: new.

312. Kunz, T. H.; and R. A. Martin. *PLECOTUS TOWNSENDII. Mammalian Species No. 175:1-6. 1982.
313. Kuss, F. R., A. R. Graefe, and J. J. Vaske. VISITOR IMPACT MANAGEMENT: A REVIEW OF RESEARCH. National Parks and Conservation Association. Washington, D.C. 362 pp. 1990.
Note: new.
314. Kuyt, E. CLUTCH SIZE, HATCHING SUCCESS, AND SURVIVAL OF WHOOPING CRANE CHICKS, WOOD BUFFALO NATIONAL PARK, CANADA. Pages 126-129 in: J. C. Lewis and H. Masatomi, eds. Crane research around the world. International Crane Foundation, Baraboo, WI. 1981.
315. Lacey, R. M., R. S. Baran, W. D. Severinghaus, and D. J. Hunt. EVALUATION OF LANDS FOR RECREATIONAL SNOWMOBILE USE (GUIDELINES FOR NATURAL RESOURCES MANAGEMENT AND LAND USE COMPATIBILITY). Construction Engineering Research Lab. (Army). Champaign, Ill. 1981.
Note: new.
316. Lavigne, G. R. WINTER RESPONSE OF DEER TO SNOWMOBILES AND SELECTED NATURAL FACTORS. M.S. thesis, University of Maine, Orono. 68 pp. plus supplement. 1976.
Snowmobile trails enhanced deer mobility during periods of deep snow in Maine, and probably reduced deer energy expenditures in winter; deer used snowmobile trails more extensively near major bedding area. Disturbance by snowmobiles did not cause deer to abandon preferred bedding and feeding sites. Deer responses to snowmobiles varied from running out of sight to staying in place, depending on conditions of the encounter (Boyle and Samson 1983).
317. Lee, M. E., D. R. Field, and K. Schwarzkopf. PEOPLE, HUMAN BEHAVIOR AND ANIMALS IN PARKS AND PRESERVES: A WORKING BIBLIOGRAPHY. Natl. Park Serv., Coop. Park Stud. Unit Publ. CPSU/OSU 84-11. Coll. For., Oregon State Univ., Corvallis. 35 pp. 1984.
Note: new.
318. Leedy, D. H. HIGHWAY-WILDLIFE RELATIONSHIPS. VOL. 1. A STATE-OF-THE-ART REPORT. Fed. Hwy. Admin., Office Res. Develop. FHWA-RD-76-5. 417 pp. 1975.
*Annotated Bibliography.
319. Leedy, D. H.; T. M. Franklin; and C. E. Hekimian. HIGHWAY-WILDLIFE RELATIONSHIPS. VOL. 2. AN ANNOTATED BIBLIOGRAPHY. Fed. Hwy. Admin., Office Res. Develop. FHWA-RD-76-5. 417 pp. 1975.
*Annotated Bibliography.
320. LeResche, R. E. BEHAVIOR AND CALF SURVIVAL IN ALASKA MOOSE. M.S. thesis; Univ. Alaska, Fairbanks. 85 pp. 1966.
Reactions of moose to human disturbance ranged from flight, through slowly drifting away, to seeming disinterest. Cows with calves were the most wary (Ream 1980).

321. Levenson, H.; and J. R. Koplin. EFFECTS OF HUMAN ACTIVITY ON PRODUCTIVITY OF NESTING OSPREYS. J. Wildl. Manage.; 48(4):1374-1377. 1984.
The authors in this study evaluated the effects of human activity on the productivity of ospreys nesting in northwestern California during the early 1970s. The major form of intense human activity in the study is logging and the authors concluded that logging operations should be designed to minimize disruption of nesting ospreys, possibly by delaying operations in the area until young have fledged.

322. Liddle, M. J. A SELECTIVE REVIEW OF THE ECOLOGICAL EFFECTS OF HUMAN TRAMPLING ON NATURAL ECOSYSTEMS. Biol. Conserv.; 7(1):17-36. 1975.

323. Lieb, J. W. ACTIVITY, HEART RATE, AND ASSOCIATED ENERGY EXPENDITURE IN ELK OF WESTERN MONTANA. Ph.D. Thesis, Univ. of Montana, Missoula. 200 pp. 1981.
Note: new.

324. Light, J. T., Jr. AN ECOLOGICAL VIEW OF BIGHORN HABITAT ON MT. SAN ANTONIO. Trans. N. Am. Wild Sheep Conf.; 1:150-157. 1971.
Ecological analysis of a California sheep range revealed relationships between bighorn habitat use and human disturbance associated with a ski resort and a summer cabin. It was found that bighorn use did not occur where human use was heavy and sheep were forced into less satisfactory habitats (Boyle and Samson 1983).

325. Lime, D. W.; D. H. Anderson; and L. D. Mech. INTERPRETING WILDLIFE THROUGH GUIDED EXPEDITIONS. J. Interpret 3(2):10-16. 1978.
Guided expeditions were initiated in the Superior National Forest of Minnesota. People participating in wolf-howling safaris and wildlife-sign safaris had fun (in spite of only indirect encounters with wildlife) and at the same time learned about wildlife. This concept could be a useful method of public education about wildlife (Ream 1980).

326. Lindberg, K. and D. E. Hawkins, eds. ECOTOURISM: A GUIDE FOR PLANNERS AND MANAGERS. The Ecotourism Society. North Bennington, Vermont. 1993.
Note: new.

327. Lindenmayer, D. B. and H. A. Nix. ECOLOGICAL PRINCIPLES FOR THE DESIGN OF WILDLIFE CORRIDORS. Conservation Biology 7:627-630. 1973.
Note: new.

328. Lindzey, F. *MOUNTAIN LION. Pages 657-668 in: M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario. 1987.

329. Lockman, D. C.; R. Wood; H. Smith; B. Smith; and H. Burgess. ROCKY MOUNTAIN TRUMPETER SWAN POPULATION-WYOMING FLOCK. 1982-86 Progress Report. Wyoming Game and Fish Dept., Cheyenne. 74 pp. 1987.

330. Lodico, N. J. ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES: A REVIEW OF THE LITERATURE. USDI Office of the Secretary, Washington, D.C. 1973.
Note: new.

331. Lodico, N. J. ENVIRONMENTAL EFFECTS OF VEHICLES: A REVIEW OF THE LITERATURE. USDI Research Services Branch, Bibliographic Service, Ofc. of Library Services, Bibliography Series No. 29. Washington, D.C. 109 pp. 1973.
Note: new.

332. Long, C. A. *MICROSOREX HOYI AND MICROSOREX THOMPSONI. Mammalian Species No. 33:1-4. 1974.
333. Lopez, B. H. *OF WOLVES AND MEN. Charles Schribner's Sons, New York. 304 pp. 1978.
334. Lyon, L. J. ROAD DENSITY MODELS DESCRIBING HABITAT EFFECTIVENESS FOR ELK. Journal of Forestry, September:592-595. 1983.
Note: new.
Forest roads evoke an avoidance response by elk.
335. MacAarthur, R. H. and E. O. Wilson. THEORY OF ISLAND BIOGEOGRAPHY. Princeton University Press, Princeton, N. J. 1967.
Note: new.
336. MacArthur, R. A.; R. H. Johnson; and V. Geist. FACTORS INFLUENCING HEART RATE IN FREE-RANGING BIGHORN SHEEP: A PHYSIOLOGICAL APPROACH TO THE STUDY OF WILDLIFE HARASSMENT. Can. J. Zool.; 57:2010-2021. 1979.
Heart rates of unrestrained female bighorn sheep were measured by telemetery in Alberta. In all ewes studied heart rate varied positively with activity level and inversely with distance from a road. Responses to other stimuli varied. Findings are discussed in relation to ecology and bioenergetics of bighorn sheep (Boyle and Samson 1983).
337. MacArthur, R. A.; V. Geist; and R. H. Johnson. CARDIAC AND BEHAVIORAL RESPONSES OF MOUNTAIN SHEEP TO HUMAN DISTURBANCE. J. Wildl. Manage.; 46:351-358. 1982.
338. MacNab, J. WILDLIFE MANAGEMENT AS SCIENTIFIC EXPERIMENTATION. Wildl. Soc. Bull. 11:397-401. 1983.
Note: new.
339. Maldague, M. IMPACT OF SNOWMOBILES ON THE FOREST ENVIRONMENT. Forest Conservation 39(9):6-8. 1973.
Note: new.
340. Manfredo, M. J., J. J. Vaske, and D. J. Decker. HUMAN DIMENSIONS OF WILDLIFE MANAGEMENT: BASIC CONCEPTS. In: Wildlife and Recreationists: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 17-31. Island Press, Washington, D.C. 1995.
Note: new.
341. Manfredo, M. J.; and R. A. Larson. MANAGING FOR WILDLIFE VIEWING RECREATION EXPERIENCES: AN APPLICATION IN COLORADO. Wildl. Soc. Bull.; 21:226-236. 1993.
342. Manning, R. E. IMPACTS OF RECREATION ON RIPARIAN SOILS AND VEGETATION. Water Resources Bulletin 50:30-43. 1979.
Note: new.
343. Manuwal, D. A. EFFECT OF MAN ON MARINE BIRDS: A REVIEW. In: Proc. Wildlife and People, C. M. Kirkpatrick, ed., pp. 140-160. Purdue Res. Foundation, West Lafayette, Ind. 1978.
Note: new.

344. March, D.; and C. Adams. A FRONT RANGE CONCEPT: THE NEED FOR THE NODDLES-RAMPART-SOUTH PLATTE RECREATION AREA. Wildlife-2000, Aurora, CO. 112 pp. plus appendices. 1973.
Results of a comprehensive study of wildlife, motorized recreation vehicles, and forest management in central Colorado are reported. Impacts of off-road vehicles on wildlife are severe, especially when engine noise is loud. Human recreational activities have accelerated habitat change which threaten vital watersheds and the wildlife which inhabit them (Boyle and Samson 1983).

345. Marshall, O. PRELIMINARY STUDIES ON THE EFFECTS OF SNOWMOBILE COMPACTION ON SOME TERRESTRIAL INVERTEBRATES. Amer. Zool. 1972.
Note: new.

346. Masyk, W. J. SNOWMOBILE, A RECREATION TECHNOLOGY IN BANFF NATIONAL PARK; ENVIRONMENTAL IMPACT AND DECISION-MAKING. Univ. of Calgary; The Univ. of Western Ontario, London, Ontario. 1973.
Note: new.

347. Mathisen, J. E. EFFECTS OF HUMAN DISTURBANCE ON NESTING BALD EAGLES. J. Wildl. Manage.; 32:1-6. 1968.
Bald eagle nesting success in Minnesota was studied in relation to intensity of several forms of human disturbance, including recreational activities. Human disturbance did not appear to significantly affect nest occupancy or nesting success (Boyle and Samson 1983).

348. Mayes, A. THE PHYSIOLOGY OF FEAR AND ANXIETY. In: Fear in Animals and Man, W. Sluckin, ed., pp. 24-55. Van Nostrand Reinhold Company, New York. 1979.
Note: new.
Physiological and behavioral responses to disturbance.

349. McClellan, B. N.; and D. M. Shackleton. IMMEDIATE REACTIONS OF GRIZZLY BEARS TO HUMAN ACTIVITIES. Wildl. Soc. Bull.; 17:269-274. 1989.
This study evaluated the responses of grizzly bears to human activities such as people on foot either next to or away from a parked vehicle, moving vehicles, heavy industrial equipment, fixed-wing aircraft, and helicopters. Bears responded more strongly to people on foot in remote areas than to any other stimuli. Management implications are discussed.

350. McCool, S. F. SNOWMOBILES, ANIMALS, AND MAN: INTERACTIONS AND MANAGEMENT ISSUES. Trans. North Amer. Wildl. and Nat. Resour. Conf. 43:140-148. 1978.
Note: new.

351. McCool, S. F. SNOWMOBILES, ANIMALS, AND MAN: INTERACTIONS AND MANAGEMENT ISSUES. The Wildlife Management Institute. Washington, D.C. 23 pp. 1978.
Note: new.

352. McCool, S. F. and B. Curtis. SOURCES OF CONFLICT AMONG WINTER RECREATIONISTS. In: Proc. North American Symposium on Dispersed Winter Recreation, pp. 73-77. Univ. of Minn. Office of Spec. Prog., Educ. Ser. 2-3. 1980.
Note: new.

353. McCord, C. M. and J. E. Cardoza. *BOBCAT AND LYNX. Pages 728-766 in: J. A. Chapman and G. A. Feldhamer, eds. Wild mammals in North America: biology, management, and economics. John Hopkins Univ. Press, Baltimore. 1982.

354. McGarigal, K.; R. G. Anthony and F. B. Issacs. INTERACTIONS OF HUMANS AND BALD EAGLES ON THE COLUMBIA RIVER ESTUARY. Wildlife Monograph; No. 15; 47p. 1991.
Note: Available at $4.50 from Wildl. Soc., 5410 Grosvenor Ln., Bethesda, MD 2014.

355. McIntyre, J. M. W. BIOLOGY AND BEHAVIOR OF THE COMMON LOON WITH REFERENCE TO ITS ADAPTABILITY IN A MAN-ALTERED ENVIRONMENT. Ph.D. Diss. Univ. of Minnesota, St. Paul. 243 pp. 1975.
Loons are subject to hazards from pollutants and increased recreational use because of their aquatic habits and conflict with man for habitat. Biological factors of loons were studied to assess their ability to adapt to these environmental changes. Their potential for maintaining stable populations in Minnesota are described based on the research results (Boyle and Samson 1983).

356. McMillan, J. F. SOME OBSERVATIONS ON MOOSE IN YELLOWSTONE NATIONAL PARK. Am. Midl. Nat.; 52(2):392-399. 1954.
In areas of heavy tourist pressure, moose develop considerable tolerance for human disturbance, moving slowly and returning soon. In a control area visitor disturbance caused moose to run from area and not return until at least the next day (Ream 1980).

357. McReynolds, H. E.; and R. E. Radtke. THE IMPACT OF MOTORIZED HUMANS ON THE WILDLIFE OF FORESTED LANDS. Pages 102-117 in: C. M. Kilpatrick. ed. Wildlife and people. Proc. of the 1978 John S. Wright Forestry Conf., 23-24 February 1978, Purdue Univ., West Lafayette, IN. 1978.
Effects of off-road vehicles on wildlife of forested lands are reviewed. Cases for and against the use of snowmobiles, motorcycles, and four-wheel drive vehicles in forests are presented. Few reliable data on off-road vehicle impacts on wildlife are available, but it is probable that indirect effects and unintentional harassment of wildlife have produced the greatest damage (Boyle and Samson 1983).

358. Meagher, M., S. Cain, T. Toman, J. Kropp, and D. Bosman. BISON IN THE GREATER YELLOWSTONE AREA: STATUS, DISTRIBUTION AND MANAGEMENT. Paper presented at the National Brucellosis Symposium, Jackson Hole, Wyo., September. 1994.
Note: new.

359. Meagher, M. THE BISON OF YELLOWSTONE NATIONAL PARK: PAST AND PRESENT. Ph.D. Dissertation, Univ. of Calif., Berkeley. 172 pp. 1970.
Note: new.

360. Meagher, M. *THE BISON OF YELLOWSTONE NATIONAL PARK. Natl. Park Serv. Sci. Monogr. 1:1-161. 1973.

361. Meagher, M. EVALUATION OF BOUNDARY CONTROL FOR BISON OF YELLOWSTONE NATIONAL PARK. Wildl. Soc. Bull.; 17:15-19. 1989.
Efforts made since 1976 to contain bison within the boundaries of Yellowstone National Park have proved to be ineffective. This paper evaluates several tactics to minimize the potential conflict of bison leaving the park. Hazing and herding activities demonstrated that bison can be moved only where they want to go. Attempts to block travel routes and harassment with various devices sometimes treated immediate problems at the locations involved, but did not change the overall direction of bison movement down the Yellowstone River. Further, these tactics apparently caused major shifts to other travel routes or sometimes displaced a conflict from 1 site to another. The author concludes that, in general, success (if any) in localized displacement of bison by human efforts will decrease and hazards to personnel will increase with these management approaches. Cropping of bison by public hunting outside the park will not change their movements, but may lessen local conflicts.

362. Meagher, M. RANGE EXPANSION BY BISON OF YELLOWSTONE NATIONAL PARK. Journal of Mammal. 70:670-675. 1989.
Note: new.
Bison use of plowed roads, an increase in numbers, acquired knowledge of new foraging areas, and the natural gregariousness of bison contributed to range expansion.

363. Meagher, M. WINTER WEATHER AS A POPULATION REGULATING INFLUENCE ON FREE-RANGING BISON IN YELLOWSTONE NATIONAL PARK. In: Research in Parks, Transactions of the National Park Centennial Symposium of the American Association for the Advancement of Science, Dec. 28-29, 1971. Ser. No. 1. Washington, D.C.: U.S. Government Printing Office. 232 pp. 1976.
Note: new.

364. Meagher, M. WINTER RECREATION-INDUCED CHANGES IN BISON NUMBERS AND DISTRIBUTION IN YELLOWSTONE NATIONAL PARK. Draft, report to management, unpublished. 48 pp. 1993.
Note: new.
Snow-packed roads used for winter recreation in the interior of the park appeared to be the major influence in major changes that occurred in bison numbers and distribution in Yellowstone, during the past decade. The entire bison population is involved, effects will ultimately occur on the ecosystem level. Range expansion, major shifts among subpopulations, mitigation of winterkill, and enhanced calf survival have resulted.

365. Meagher, M. WINTER RECREATION-INDUCED CHANGES IN BISON NUMBERS AND DISTRIBUTION IN YELLOWSTONE NATIONAL PARK. Unpublished. 1993.
Note: new.

366. Mech, L. D. *CANIS LUPUS. Mammalian Species No. 37. 6 pp. 1974.

367. Mech, L. D. *THE WOLF-THE ECOLOGY AND BEHAVIOR OF AN ENDANGERED SPECIES. Natural History Press, Doubleday, New York. 384 pp. 1970.

368. Mech, L. D. THE WOLVES OF ISLE ROYALE. Fauna of the National Parks of the U.S.; Fauna Series No. 7, U.S. Govt. Printing Office, Washington, D.C. 219 pp. 1966.
Gives occasional insights into the responses of wolves to the researcher on the ground, and to the aircraft used for observations. The researcher was not threatened by wolves, even when he examined recent kills. the wolves became habituated to the airplane used for observations and usually did not run even when repeatedly buzzed as low as 40 feet (Ream 1980).

369. Mech, L. D.; S. H. Fritts; G. L. Radde; and W. J. Paul. WOLF DISTRIBUTION AND ROAD DENSITY IN MINNESOTA. Wildl. Soc. Bull.; 16:85-87. 1988.

370. Mech, L. D.; T. J. Meier; and J. W. Burch. DENALI PARK WOLF STUDIES: IMPLICATIONS FOR YELLOWSTONE. Trans. N. Am. Wildl. Nat. Res. Resour. Conf.; 56:86-90. 1991.

371. Mech. L. D. WOLF POPULATION SURVIVAL IN AN AREA OF HIGH ROAD DENSITY. Am. Midl. Nat.; 121:387-389. 1989.

372. Melquist, W. E.; and M. G. Hornocker. *ECOLOGY OF RIVER OTTERS IN WEST CENTRAL IDAHO. Wildl. Monogr. No. 83:1-60. 1983.

373. Melquist, W. E.; and A. Dronkert. *RIVER OTTER. Pages 625-641 in: M. Novak; J. A. Baker; M. E. Obbard; and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources. Ontario. 1987.

374. Mietz, J. D. SNOWMOBILE IMPACT ON FOREST VEGETATION AT HEIBERG FOREST, NEW YORK. State University of New York, College of Environmental Science and Forestry, Syracuse. 1974.
Note: new.

375. Miller, S. G. and R. L. Knight. IMPACTS OF RECREATIONAL TRAILS ON AVIAN COMMUNITIES. In: Abstracts from the Society of Conservation Biology Meeting. Dept. of Fishery and Wildlife Biology, Colorado State University, Fort Collins. 1995.
Note: new.

376. Moen, A. N., S. Whittemore, and B. Buxton. EFFECTS OF DISTURBANCE BY SNOWMOBILES ON HEART RATE OF CAPTIVE WHITE-TAILED DEER (*Odocoileus virginianus*). New York Fish and Game Journal 29(2):176-183. 1982.
Note: new.

377. Moen, A. N. ENERGY CONSERVATION OF THE WHITE-TAILED DEER IN THE WINTER. Ecology; 57(1):102-198. 1976.
Analyzes energy-conserving behavioral adaptations of white-tailed deer in northwestern Minnesota during winter. Energy conservation of up to 1,000 Kcal/day for a 60 kg deer can result from reduced activity levels (seeking level land and lesser snow depth, walking slowly, etc.). Winter harassment by dogs or snowmobile traffic is detrimental to these adaptations (Ream 1980).

378. Moen, A. N. SEASONAL CHANGES IN HEART RATES, ACTIVITY METABOLISM, AND FORAGE INTAKE OF WHITE-TAILED DEER. J. Wildl. Manage.; 42(4):715-738. 1978.
White-tailed deer exhibited seasonal rhythms in heart rates, activities, and metabolism, with the lowest ecological metabolism occurring in the winter and highest in the summer. This rhythm is an adaptation for energy conservation; resource needs are lower when range resources are reduced. As metabolism rises in March and April, the intake of dormant forage should also rise until more digestible spring growth is available. The timing of the arrival of spring seems to be an important factor in population dynamics, with its effect being more pronounced 2 years later when the fawns should become members of the breeding population.

379. Montana Department of Fish, Wildlife and Parks. PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT. Montana Snowmobile Grant Program. Prepared by Statewide Trails Program Coordinator, Montana Dept. of Fish, Wildlife and Parks, 1420 E. Sixth Ave., Helena, Mont. 59620. 1993.
Note: new.

380. Montopoli, G. L. and D. A. Anderson. LOGISTICAL MODEL FOR THE CUMULATIVE EFFECTS OF HUMAN INTERVENTION ON BALD EAGLE HABITAT. Jour. Wildl. Manage. 55:290-293. 1991.
Note: new.

381. Morgantini, L. E.; and R. J. Hudson. HUMAN DISTURBANCE AND HABITAT SELECTION IN ELK. in: Symposium on Elk Ecology and Management, pp. 132-139; Laramie, WY. 1978 Apr 3.
Habitat selection by elk was not simply related to weather conditions or available food. Passive harassment resulting from human activities (vehicular and hunting) reduced elk use of open grassland (transected by roads) and caused overgrazing of marginal areas (away from roads). This may be especially hard on elk during severe winters when energy budgets are stressed (Ream 1980).

382. Morrison, J. R. EFFECTS OF SKI AREA EXPANSION ON ELK AND ACCURACY OF TWO TELEMETRY SYSTEMS IN MOUNTAINOUS TERRAIN. M. S. Thesis, Colorado State University, Fort Collins, Colo. 98 pp. 1992.
Note: new.

383. Murphy, J. R. NEST SITE SELECTION BY THE BALD EAGLE IN YELLOWSTONE NATIONAL PARK. Utah Acad. Sci. Arts Let. Proc. ; 42:261-264. 1965.
Along with proximity to water and food sources, human disturbance is suggested as an important factor determining bald eagle nest site selection in Yellowstone National Park. Instances of apparent disruption of bald eagle nesting by human intrusions are cited.

384. National Park Foundation. NATIONAL PARKS FOR THE 21st CENTURY-THE VAIL AGENDA. Report and recommendations to the Director of the National Park Service. Capital City Press, Montpelier, VT. 1992.

385. Neil, P. H.; R. W. Hoffman; and R. B. Gill. EFFECTS OF HARASSMENT ON WILD ANIMALS—AN ANNOTATED BIBLIOGRAPHY OF SELECTED REFERENCES. Colorado Division of Wildlife; Special Rep. No. 37, Denver. 21 pp. 1975.
Annotated Bibliography: This is a compilation of 68 annotated references dealing with the many forms of harassment of wild mammals and birds in their natural habitats. Emphasis in this bibliography is principally on the effects of off-the-road vehicles, free-roaming pets, urbanization and other habitat alterations, and hunting.

386. Nelson, M. E.; and L. D. Mech. RELATIONSHIP BETWEEN SNOW DEPTH AND GRAY WOLF PREDATION ON WHITE-TAILED DEER. J. Wildl. Manage.; 50(3):471-474. 1986.
Survival of 203 yearling and adult white-tailed deer was monitored for 23,441 deer days from January through April 1975-85 in northeastern Minnesota. Gray wolf predation was the primary mortality cause, and from year to year during this period, the mean predation rate ranged from 0.000 to 0.029. The sum of weekly snow depths/month explained 51% of the variation in annual wolf predation rate, with the highest predation during the deepest snow.

387. Nero, R. W. *THE GREAT GRAY OWL: PHANTOM OF THE NORTHERN FOREST. Smithsonian Institution Press,. 0167.

388. Neumann, P. W.; and H. G. Merriam. ECOLOGICAL EFFECTS OF SNOWMOBILES. Can. Field-Nat.; 86:207-212. 1972.
Studies in Ontario showed that snowmobiles caused significant changes in snow structure and wildlife behavior. Snowmobile use affected snowshoe hare and red fox mobility and distribution, and caused significant damage to browse plants (Boyle and Samson 1983).

389. Newby, F. E.; and P. L. Wright. *DISTRIBUTION AND STATUS OF THE WOLVERINE IN MONTANA. J. Mammal.; 36:248-253. 1955.

390. Newby, F. E.; and J. J. McDougal. *RANGE EXTENSIONS OF THE WOLVERINE IN MONTANA. J. Mammal.; 45:485-487. 1964.

391. Newton, I. *POPULATION ECOLOGY OF RAPTORS. Buteo Books, Vermillion, SD (397pp). 1979.

392. Norris, R. A. *COMPARATIVE BIOSYSTEMATICS AND LIFE HISTORY OF THE NUTHATCHES, SITTA PYGMAEA AND SITTA PUSILLA. Univ. Calif. Publ. Zool; 56:119-300. 1958.

393. Noss, R. F. and A. Y. Cooperrider. SAVING NATURE'S LEGACY: PROTECTING AND RESTORING BIODIVERSITY. Island Press, Washington, D.C. 1994.
Note: new.

394. Nyran, R. B.; and M. C. Jansson. PERCEPTION OF WILDLIFE HAZARD IN NATIONAL PARK USE. Trans. N. Am. Wildl. Nat. Resour. Cong.; 38:281-295. 1973.
Increased visitation to North American National Parks is resulting in more people-wildlife encounters, thus generating crucial management problems. Park management policies are subject to public opinions, which in turn depend on public perceptions. Results of a study to determine visitor perceptions of wildlife hazard in western National Parks are reported and management implications are discussed (Boyle and Sampson 1983).

395. Odum, E. P. TRENDS EXPECTED IN STRESSED ECOSYSTEMS. BioScience 35:419-422. 1985.
Note: new.
396. O'Farrell, M. J. *STATUS REPORT: EUDERMA MACULATUM. Report to USDI, U.S. Fish Wildl. Serv., Albuquerque. 28 pp. 1981.
397. O'Farrell, M. J.; and E. H. Studier. *MYOTIS THYSANODES. Mammalian Species No. 137. 5 pp. 1980.
398. O'Farrell, M. J.; and E. H. Studier. *REPRODUCTION, GROWTH AND DEVELOPMENT IN MYOTIS THYSANODES AND M. LUCIFUGUS (CHIROPTERA: VESPERTILIONIDAE). Ecology; 54:18-30.
399. Olsen, D. L.; D. R. Blankenship; R. C. Erickson; R. Drewien; H. D. Irby; R. Lock; and L. S. Smith. WHOOPING CRANE RECOVERY PLAN. USDI, U.S. Fish and Wildlife Service; Washington, D.C. 206 pp.
This recovery plan presents information on the history, biology, and status of the whooping crane, and detailed management plans aimed at restoring the whooping crane to nonendangered status. Among factors believed responsible for the near extinction of the species are various forms of indirect and direct human disturbance. Whoopers seem to tolerate some disturbance, but only for short periods of time and if no obvious threats occur (Boyle and Samson 1983).
400. Olson, S. T.; and W. Marshall. THE COMMON LOON IN MINNESOTA. Occasional Paper #5, Minnesota Mus. Nat. History, Univ. Minnesota Press, Minneapolis. 77 pp. 1952.
401. Olson, S. L.; and W. D. Edge. *NEST SITE SELECTION BY MOUNTAIN PLOVERS IN NORTHCENTRAL MONTANA. J. Range Manage.; 38:280-282. 1985.
402. Otvos, I. S. *ARTHROPOD FOOD OF SOME FOREST-INHABITING BIRDS. Can. Entomol.; 117:971-990. 1985.
403. Packard, J.; and L. D. Mech. *POPULATION REGULATION IN WOLVES. Pages 135-150 in: M. N. Cohen, R. S. Malpass, and H. G. Klein, eds. Biosocial mechanisms of population regulation. Yale University Press, New Haven. 406 pp. 1980.
404. Palmer, D. A. *HABITAT SELECTION, MOVEMENTS AND ACTIVITY OF BOREAL AND SAW-WHET OWLS. M.S. thesis; Colorado State Univ., Fort Collins. 101 pp. 1986.
405. Park, E. *THE WORLD OF THE OTTER. J. B. Lippencott, Philadelphia. 159 pp. 1971.
406. Parker, K. L.; C. T. Robbins; and T. A. Hanley. ENERGY EXPENDITURES FOR LOCOMOTION BY MULE DEER AND ELK. J. Wildl. Manage.; 48(2):474-488. 1984.
Energy expenditures for several activities were measured using indirect calorimentry with 5 mule deer and 8 elk. The average energetic increment of standing over lying was 25%. Net energy costs (kcal/kg/km) of horizontal locomotion without snow decreased as a function of increasing body weight. The average cost per kilogram for each vertical meter climbed on a 14.3 degree incline was 5.9 kcal. Efficiency of upslope locomotion averaged 40-45% for the two species; downslope efficiency decreased with increasing body size. Energy expenditures for locomotion in snow increased curvilinearly as a function of snow depth and density. To further understand the energetics of locomotion in snow, foot loading and leg length were measured. Management implications, based on

the costs of locomotion for mule deer and elk when disturbed by winter recreationists and when traversing the slash deposition of logging operations are discussed.

407. Pederson, R. J. MANAGEMENT AND IMPACTS OF ROADS IN RELATION TO ELK POPULATIONS. In: Conf. Proc. Recreational Impact on Wildlands, R. Ittner, D. R. potter, J. K. Agee, and S. Anschell, eds., pp. 169-173. U.S. Forest Serv., U.S. Natl. Park Serv. R-6-001-1979. 1979.
Note: new.
Construction of roads in elk habitat effectively eliminated prime areas from elk production.

408. Pedevillano, C. and R. G. Wright. INFLUENCE OF VISITORS ON MOUNTAIN GOAT ACTIVITIES IN GLACIER NATIONAL PARK. Biological Conservation 39:1-11. 1987.
Note: new.
Goats at mineral licks apparently not disturbed by visitors, but goats attempting to cross goat underpasses were negatively affected by numbers of vehicles on the highway.

409. Peek, J. and D. B. Siniff. WILDLIFE-SNOWMOBILE INTERACTION PROJECT: PROGRESS REPORT. Univ. Minnesota Dept. Entom., Fish, Wildl., Ecol. and Behav. Biol., and Minn. Dept. of Natural Resources, St. Paul. 1972.
Note: new.

410. Pelton, M. R. *BLACK BEAR (URSUS AMERICANUS). Pages 504-514 in: J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: biology, management, and economics. John Hopkins University Press, Baltimore. 1982.

411. Perkins, M. *THE PLIGHT OF PLECOTUS. Bats; 2:1-3. 1985.

412. Perry, C. and R. Overly. IMPACT OF ROADS ON BIG GAME DISTRIBUTION IN PORTIONS OF THE BLUE MOUNTAINS OF WASHINGTON, 1972-1973. Washington Game Department. 1976.
Note: new.
General reduction of use up to 1/8 mile from roads, depending on amount of roadside cover; deer substantially affected in meadows when cover was lacking.

413. Peters, R. P.; and L. D. Mech. *SCENT-MARKING IN WOLVES. American Scientist: 63:628-637. 1975.

414. Peterson, R. O. MANAGEMENT IMPLICATION OF WOLF-MOOSE RESEARCH, ISLE ROYALE NATIONAL PARK, MICH. Rept. to the Natl. Park Serv. 14 pp. 1977.
Wolves of Isle Royale tend to avoid contact with humans. Wolf use of park trails declines after visitors arrive in the spring. Selection of den and rendezvous sites indicates pronounces avoidance of humans. Management suggestions include limiting visitation, enlarging existing backcountry campsites rather than establishing new campgrounds, no further trail development, and discouragement of winter visitor use (Ream 1980).

415. Pomerantz, G. A.; D. J. Decker; G. R. Goff; and K. G. Purdy. ASSESSING IMPACT OF RECREATION ON WILDLIFE: A CLASSIFICATION SCHEME. Wildl. Soc. Bull.; 16:58-62. 1988.

416. Poole, A. THE EFFECTS OF HUMAN DISTRUBANCE ON OSPREY REPRODUCTIVE SUCCESS. Colon. Waterbirds; 4:20-27. 1981.
Effects of visits to osprey nests by researchers, trapping of breeding adults, and other human activities near nests were studied on the Atlantic coast from New York City to Boston, Massachusetts, and in Everglade National Park, Florida. No evidence was found of adverse effects of osprey reproduction from nest visits, although climbing nest trees may increase raccoon predation on young or eggs. Nests exposed to nearly continuos human activity produced young at rates equivalent to wilderness nests (Boyle and Samson 1983).
417. Potter, D. R.; K. M. Sharpe; and J. C. Hendee. HUMAN BEHAVIOR ASPECTS OF FISH AND WILDLIFE CONSERVATION: AN ANNOTATED BIBLIOGRAPHY. USDA, U.S. For. Ser. Gen. Tech. Rep. PNW-4. 288 pp. 1973.
Annotated Bibliography.
418. Powell, R. A. *THE FISHER-LIFE HISTORY, ECOLOGY AND BEHAVIOR. Univ. Minnesota Press, Minneapolis. 217 pp. 1982.
419. Progulske, D. R.; and T. S. Baskett. MOBILITY OF MISSOURI DEER AND THEIR HARASSMENT BY DOGS. J. Wildl. Manage.; 22(2):184-192. 1958.
420. Pruitt, W. O. SNOWMOBILES AND ALL-TERRAIN VEHICLES. Paper presented at Conference on Snowmobiles and All-Terrain Vehicles. Univ. of Western Ontario, Dept. Zool. Res. Report, University of Manitoba, Winnipeg, Canada. 1971.
Note: new.
Discussed impacts of snowmobiles on the subnivean environment.
421. Purdy, K. G., G. R. Goff, D. J. Decker, G. A. Pomerantz, and N. A. Connelly. GUIDE TO MANAGING HUMAN ACTIVITY ON NATIONAL WILDLIFE REFUGES. USDI Fish and Wildlife Service, Office of Information Transfer. Fort Collins, Colorado. 1987.
Note: new.
422. Purves, H. D.; C. A. White; and P. C. Paquet. WOLF AND GRIZZLY BEAR HABITAT USE AND DISPLACEMENT BY HUMAN USE IN BANFF, YOHO, AND KOOTENAY NATIONAL PARKS: A PRELIMINARY ANALYSIS. Heritage Resources Conservation, Canadian Parks Service, Banff, AB. 1992.
The SPANS Geographic Information System was used to analyze observations of radio collared wolves and grizzly bears. The value of existing habitat suitability models was tested for these two species, as well as the human displacement effect of varying intensities of human activity. Human activity levels were classified using an exponential scale of monthly traffic on human use vectors (roads and trails), or monthly person/days of use for human use points and polygons (campsites, towns, and ski areas).
Within Banff National Park (BNP) over 91% of the wolf telemetery observations occurred within ecosites rated as high and very high habitat capability. Most wolf observations were in the Bow Valley between Vermillion Lakes and Bow Lake and in the Spray Valley to Kananaskis Country. Wolves used the valley bottoms for travel corridors but showed aversion to regions where winter human use exceeded 10,000 visitors per month. The town of Banff has created a partial blockage to wolf movement denying wolves access to prime habitat east of the town.

Only 51% of the grizzly bear observations were in ecosites rated as high and very high capability within BNP, Yoho National Park (YNP), and Kootenay National Park (KNP). Of ten radio collared bears, four were habituated to humans, and therefore removed from future data analysis. Grizzly bear tolerance to human use was found to be within the range of 1,001-10,000 visitors per month. In the three parks, 335 square kilometers of available habitat were found to have use levels which exceeded the tolerance of non-habituated bears.

Given the displacement of wolves and grizzly bears by current human use levels in BNP, YNP, and KNP, and forecasted increases in visitation to these parks, management of human use is essential if humans, wolves, and grizzly bears are to continue to coexist. An objective of "no-net-loss" for carnivore habitat must be accepted by the Canadian Parks Service (CPS). A possible management strategy is to accommodate increased human activity in areas where wolves and grizzly bears have been totally displaced, and discourage increased human use of areas still used by these carnivores. In all cases, carnivore migration corridors must be preserved or widespread habitat alienation can occur.

As part of cumulative effects management, knowledge of displacement must be integrated with other factors that affect the survival of wolves and grizzly bears in the Canadian Rockies. It is recommended that a standing Environmental Assessment and Review Process (EARP) Panel should be established immediately to ensure that cumulative effects are recognized in preserving carnivores in YNP, KNP, and BNP.

423. Quinn, N. W. S.; and G. Parker. *LYNX. Pages 682-695 in: M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario. 1987.

424. Rabb, G. B. *REPRODUCTIVE AND VOCAL BEHAVIOR IN CAPTIVE PUMAS. J. Mammal.; 40:616-617. 1959.

425. Rapport, D. J., H. A. Regier, and T. C. Hutchinson. ECOSYSTEM BEHAVIOR UNDER STRESS. American Naturalist 125:617-640. 1985.
Note: new.

426. Ream, C. H. HUMAN-WILDLIFE CONFLICTS IN BACKCOUNTRY: POSSIBLE SOLUTIONS. Page 153-163 in: R. Ittner, D. R. Potter, J. K. Agee, and S. Anschell, eds. Recreational impacts on wildlands. Conf. Proc., 27-29 October 1978, Seattle, WA. U.S. For. Serv. R-6-001-1979. 1979.
Increasing backcountry recreational use and diminishing wildlands contribute to growing pressures on wildlife in backcountry areas. The extent of human impacts and possible solutions are reviewed. Deliberate harassment sometimes occurs, but the major impact of humans on wildlife results from unintentional disturbance. Management of people, wildlife, and habitat may be necessary to reduce human-wildlife conflicts (Boyle and Samson 1983).

427. Ream, C. H. IMPACT OF BACKCOUNTRY RECREATIONISTS ON WILDLIFE: AN ANNOTATED BIBLIOGRAPHY. USDA, U.S. For. Serv. Gen. Tech. Rep. INT-84. 1980.
*Annotated Bibliography.

428. Redmond, R. L.; and D. A. Jenni. *NATAL PHILOPATRY AND BREEDING AREA FIDELITY OF LONG-BILLED CURLEWS: PATTERNS AND EVOLUTIONARY CONSEQUENCES. Behavioral Ecology and Sociobiology; 10:277-279. 1982.

429. Redmond, R. L.; and D. A. Jenni. *POPULATION ECOLOGY OF LONG-BILLED CURLEWS IN WESTERN IDAHO. Auk; 103:755-767. 1986.

430. Regelin, W. L., C. C. Schwartz, and A. W. Franzmann. SEASONAL ENERGY METABOLISM IN MOOSE. J. Wildl. Manage. 49:388-393. 1985.
Note: new.

431. Reid, M.; R. Mule; and B. Renfrow. ASSESSMENT OF GRIZZLY BEAR UTILIZATION AND HABITAT QUALITY IN THE CLARK'S FORK SNOWMOBILE TRAIL CORRIDOR. Prep. for Douglas Hart B-4 Ranch. Prep. by KRA Nat. Resour. Consultants, Bozeman, MT. 54 pp. 1983.

432. Reid, N. J. PUBLIC VIEW OF WILDLIFE. Pages 77-80 in: Towards a new relationship of man and nature in temperate lands. Part 1: Ecological impact of recreation and tourism upon temperate environments. IUCN Tenth Technical Meeting, 26-30 June 1966, Lucerne, Switzerland, IUCN Publ. New Serv. 7, Morges, Switzerland. 1967.
Techniques for providing public viewing of wildlife in U.S. National Parks are discussed. Sound ecological management of parks resources can greatly improve wildlife viewing, and special viewing facilities and devices are suggested for increasing viewing opportunities. Park roads are often major viewing points in National Parks. Visitors should be encouraged to adjust their schedules to take advantage of seeing wildlife at their most active times (Boyle and Samson 1983).

433. Reinecke, K.; and D. Delnicki. DUCKDATA; A BIBLIOGRAHIC DATA BASE FOR NORTH AMERICAN WATERFOWL (ANATIDAE) AND THEIR WETLAND HABITATS. USDI, U.S. Fish Wildl. Ser. Res. Pub. 188. 1992.
*Annotated Bibliography (available from authors on formatted user-supplied diskettes in ProCite format, contains some 9,000 citations).

434. Renecker, L. A. and R. J. Hudson. SEASONAL ENERGY EXPENDITURES AND THERMOREGULATORY RESPONSES OF MOOSE. Can. Jour. Zoology 64:322-327. 1986.
Note: new.

435. Richens, V. B.; and G. R. Lavigne. RESPONSE OF WHITE-TAILED DEER TO SNOWMOBILES AND SNOWMOBILE TRAILS IN MAINE. Can. Field-Nat.; 92:334-344. 1978.
Studies of deer responses to snowmobiles in Maine revealed that deer were not driven from the area by snowmobiles and frequently followed snowmobile trails where the snow was firmer. It is suggested that snowmobiles could be used to manage deer in winter by providing trails where walking in snow is easier and inducing winter movements to suitable habitat (Boyle and Samson 1983).

436. Rocky Mountain/Southwestern Recovery Team. *AMERICAN PREGRINE FALCON RECOVERY PLAN (ROCKY MOUNTAIN, SOUTHWEST POPULATIONS). U.S. Fish Wildl., Denver, CO. 183 pp. 1977.

437. Roggenbuck, J. W. USE OF PERSUASION TO REDUCE RESOURCE IMPACTS AND VISITOR CONFLICTS. In: Influencing Human Behavior, M. J. Manfredo, ed., pp. 149-208. Sagamore Publishing, Inc. Champaign, Ill. 1992.
Note: new.

438. Rolley, R. E. *BOBCAT. Pages 670-681 in: M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario. 1987.

439. Rongstad, O. J. RESEARCH NEEDS ON ENVIRONMENTAL IMPACTS OF SNOWMOBILES. In: Off-road Vehicle Use: A Management Challenge, N. Andrews, L. Richard, and P. Nowak, eds., USDA Ofc. of Environmental Quality. Washington, D.C. 1980.
Note: new.

440. Rosenmann, M. and P. Morrison. PHYSIOLOGICAL CHARACTERISTICS OF THE ALARM REACTION IN THE DEER MOUSE. Physiological Zoologica 47:230-241. 1974.
Note: new.

441. Rost, G. A. and J. A. Bailey. DISTRIBUTION OF MULE DEER AND ELK IN RELATION TO ROADS. J. Wildl. Manage. 43:634-641. 1979.
Note: new.

442. Rost, G. R. RESPONSE OF DEER AND ELK TO ROADS. M.S. thesis; Colorado State University, Fort Collins. 51 pp. 1975.
Responses of deer and elk to roads on winter ranges in Colorado were studied by counting fecal pellet groups along transects perpendicular to roads. Deer and elk apparently avoided areas near roads, particularly areas within 200 meters of roads. Deer avoided even dirt roads, some of which were used only by four-wheel drive vehicles, trailbikes, and hikers (Boyle and Samson 1983).

443. Rost, G. R.; and J. A. Bailey. RESPONSES OF DEER AND ELK TO ROADS ON THE ROOSEVELT NATIONAL FOREST. Dept. Fish and Wildl. Biol., Colo. St. Univ., Ft. Collins. 19 pp. (mimeo). 1974.
In the mountain shrub and ponderosa pine vegetation zones on the Roosevelt National Forest, Colorado, deer and elk pellet-groups densities increased with distance from roads. Deer avoidance of roads was greater in the ponderosa pine zone. Paved, gravel and unimproved dirt roads were avoided. Limited data for elk indicated that elk avoid gravel roads but not dirt roads, which are usually snowbound when elk are present, in the ponderosa pine zone. It is not known if deer or elk will avoid roads to an extent that is detrimental to their welfare (Neil et al. 1975).

444. Ruggiero, L. F., G. D. Hayward, and J. R. Squires. VIABILITY ANALYSIS IN BIOLOGICAL EVALUATIONS: CONCEPTS OF POPULATION VIABILITY ANALYSIS, BIOLOGICAL POPULATION, AND ECOLOGICAL SCALE. Conservation Biology 8(2):364-372. 1994.
Note: new.
Reviewed population viability analysis (PVA). Suggested that assessments must address population persistence and habitat dynamics. A 7-step guide for PVA was provided.

445. Russell, D. OCCURRENCE AND HUMAN DISTURBANCE SENSITIVITY OF WINTERING BALD EAGLES ON THE SAUK AND SUIATTLE RIVERS, WASHINGTON. In: Proceedings of Washington Bald Eagle Symposium, R. L. Knight, G. T. Allen, M. V. Stalmaster, and C. W. Servheen, eds., pp. 165-174. 1980.
Note: new.

446. Sachet, G. A. INTEGRATED TRAIL PLANNING GUIDELINES FOR WILDLIFE, RECREATION AND FISH RESOURCES ON MT. HOOD NATIONAL FOREST. USDA Forest Service. 1990.
Note: new.

447. Saltz, D.; and G. C. White. URINARY CORTISOL AND UREA NITROGEN RESPONSES TO WINTER STRESS IN MULE DEER. J. Wildl. Manage.; 55(1):1-16. 1991.
The authors investigated the urinary cortisol and urea nitrogen responses of mule deer in winter population densities. Urine cortisol, assumed to reflect energy deficit, allows researchers to distinguish high levels of urea nitrogen caused by the availability of crude protein from those caused by muscle catabolism. The authors concluded that by reflecting both environmental and animal condition, urine cortisol provides a tool for assessing population condition and ecological density.

448. Salwasser, H. and F. Samson. CUMULATIVE EFFECTS ANALYSIS: AN ADVANCE IN FOREST PLANNING AND WILDLIFE MANAGEMENT. Tran. No. Amer. Wildl. and Nat. Res. Conf. 50:313-321. 1985.
Note: new.

449. Salwasser, H., C. Schoenwald-Cox, and R. Baker. ROLE OF INTERAGENCY COOPERATION IN MANAGING FOR VIABLE POPULATIONS. In: Viable Populations for Conservation, M. E. Soule, ed., pp. 159-173. Cambridge University Press. 1972.
Note: new.

450. Samuel, M. D. and R. E. Green. A REVISED TEST PROCEDURE FOR IDENTIFYING CORE AREAS WITHIN THE HOME RANGE. J. An. Ecology 57:1067-1068. 1988.
Note: new.
Revised his 1985 paper in same journal.

451. Schaller, G. B. *THE BREEDING BEHAVIOR OF THE WHITE PELICAN AT YELLOWSTONE LAKE, WYOMING. Condor; 66(1):3-23. 1964.

452. Schleyer, B. O. ACTIVITY PATTERNS OF GRIZZLY BEARS IN THE YELLOWSTONE ECOSYSTEM AND THEIR REPRODUCTIVE BEHAVIOR, PREDATION, AND USE OF CARRION. M. S. thesis, Montana State Univ., Bozeman. 1983.
Note: new.

453. Schmid, W. D. MODIFICATION OF THE SUBNIVEAN MICROCLIMATE BY SNOWMOBILES. In: Snow and Ice in Relation to Wildlife and Recreation, Symposium Proceedings, pp. 251-257. Coop. Wildl. Res. Unit, Iowa State Univ., Ames. 1971.
Note: new.

454. Schmid, W. D. SNOWMOBILE ACTIVITY, SUBNIVIAN MICROCLIMATE AND WINTER MORTALITY OF SMALL MAMMALS. Bull. Ecol. Soc. Am.; 53(2):37 (Abstract only).
Compaction of snowfields by snowmobiles alters the mild snow microclimate, potentially affecting organisms that live within or beneath the snow by increasing temperature stress or restricting movement. Experimental manipulation of a snowfield showed that winter mortality of small mammals was significantly increased by snowmobile compaction (Boyle and Samson 1983).

455. Schullery, P. *THE BEARS OF YELLOWSTONE. Yellowstone Library and Museum Assoc., Yellowstone National Park, WY. 176 pp. 1980.

456. Schultz, R. D. RESPONSES OF NATIONAL PARK ELK TO HUMAN ACTIVITY. M.S. thesis. Univ. of Montana. 95 pp. 1975.
Note: new.

457. Schultz, R. D.; and J. A. Bailey. RESPONSES OF NATIONAL PARK ELK TO HUMAN ACTIVITY. J. Wildl. Manage.; 42(1):91-100. 1978.
Responses of elk to human activities near a road were quantified for fall, winter, and spring in Rocky Mountain National Park. These elk, which experienced little or no hunting, were not significantly affected by normal on-road visitor activities (Ream 1980).

458. Scom, A. J., G. Bollinger, and O. J. Rongstad. STUDYING THE EFFECTS OF SNOW-MOBILE NOISE ON WILDLIFE. Internoise Proceedings 236-241. 1972.
Note: new.

459. Scott, P.; and the Waterfowl Trust. *THE SWANS. Houghton Mifflin, Boston. 242 pp. 1972.

460. Seidensticker, J. C., IV; M. G. Hornocker; W. C. Wiles; and J. P. Messick. *MOUNTAIN LION SOCIAL ORGANIZATION IN THE IDAHO PRIMITIVE AREA. Wildl. Monogr. No. 35:1-60. 1973.

461. Serveen, C. W. ECOLOGY OF THE WINTERING BALD EAGLES ON THE SKAGIT RIVER, WASHINGTON. M.S. thesis; University of Washington, Seattle. 96 pp. 1975.
Bald eagle distributions in winter on the Skagit River, Washington, were related to habitat factors including human activity. Eagles initially utilized areas isolated from a road and receiving little human use, and only when food became less available in these areas were areas with more human activity utilized (Boyle and Samson 1983).

462. Several. SNOWMOBILES VERSUS WOLVES. International Wolf. 1992 Mar.
In response to the concern that snowmobile use may be harmful to wolf survival, the staff of “International Wolf” polled 40 wolf biologists with the question, “do you believe that snowmobiles are harmful to wolves in any way other than to provide accessibility to kill or harass them?” Excerpts from the seventeen biologists who responded are as follows:

Anonymous: “Snowmobile traffic may benefit wolves by packing the snow and allowing more efficient travel, particularly in deep snow. This probably allows more packs to travel their territories more rapidly, hunt more effectively, and advertise their territory (via scent marking and howling) more effectively. However, there must be some level of snowmobile traffic at which disturbance becomes detrimental. This may be 5 to 100 times the current level within wolf territories, but undoubtedly there exists some threshold at which the network of snowmobile trails and frequency of passage of snowmobiles would preclude wolf occupancy.”

Berg, B., Wildlife Biologist, Department of Natural Resources, Minnesota: “Unless a snowmobiler is hell-bent on killing a wolf, snowmobiles traveling on established trails likely have little or no adverse impacts on wolves. Rather, snowmobiles trails may help both wolves and deer by providing ease of access to other habitats and food sources. Most snowmobile trails and secondary roads in Minnesota have wolf tracks on them, and many wolf pack territories in northern Minnesota contain or border on snowmobile trails.

With Minnesota’s wolf population stable to slightly increasing, there is no reason to believe that average snowmobile traffic on established trails has any adverse effect.”

Burch, J. Denali National Park, Alaska: “Wolves are smart, tough, adaptive animals both as individuals and as a species. There are several observations from both Alaska and Minnesota of wolves becoming accustomed to mechanized equipment. Wolves have proved their ability to deal with these disturbances and go on about their business as though they did not exist.”

Darby, W. R. Ministry of Natural Resources, Ontario, Canada: “Snowmobile trails probably benefit wolves by making travel and access to prey easier.”

Fuller, T. Asst. Prof., University of Massachusetts: “It seems clear that when no harassment is involved, and when the presence of vehicles does not otherwise disrupt normal behaviors, such vehicles likely are not harmful. However loud and unaesthetic snowmobiles may be to some people, wolves likely can adapt to them as long as there is no direct influence on behavior or survival.”

Haber, G., Wildlife Scientist, Denali Park, Alaska: If there are wolves in the area, there could be unintentional harassment. If there is a snow machine buzzing around them, wolves are likely to exit that immediate area, at least temporarily, whether the driver is intentionally after them or not.”

Herbert, D., Integrated Environmental Resource Manger, Alberta-Pacific Forest Industries, Inc., Canada: “Depending on the density of snowmobile activity and the size of the habitat area, I believe that most animals can accommodate this activity with short movements. Obviously, there is an activity level, even without harassment, that would limit accommodating movements”.

“Although some evidence shows a change in [wolves] physiological response (heart rate), it has not been translated to increased mortality, body weight loss, etc. It is highly unlikely that this activity will affect wolf survival. It certainly won’t in Canada. There is a possibility it might in Minnesota. However, if snowmobile activity reaches that level, it probably isn’t safe for humans either.”

Kunkel. K. E., Graduate Research Assistant, University of Montana: “As long as the miles of trails in a given area don’t reach a density where security cover for wolves is greatly diminished, the impact should be minimal. What this trail density is, is probably unknown, but I can think of no trail system in the northeastern portion of Minnesota where it is excessive and can’t imagine such a system developing and being consistently used.”

Mech, L. D., Wolf Biologist, National Biological Survey, Minnesota: "In my experience, wolves readily adapt to traffic and noise of snowmobiles just as they do to those of vehicles. I know of many wolf pack territories through which snowmobiles pass regularly every winter and have never seen any evidence of harm to wolves from them."

Nelson. M., Wildlife Research Biologist, U.S. Fish and Wildlife Service, Minnesota: "Except for providing human accessibility to wolves, snowmobiles seem to present no direct threat to wolves. My observations of wolves in forested habitat indicate that wolves appear indifferent to snowmobile traffic that is not close to them (*i.e.,* farther away that 100-220 yards). This is the same apparent indifference wolves display toward vehicular traffic, heavy machinery and walking humans at similar distances."

Meier, T., Denali National Park, Alaska: I'm disturbed by the tendency to use wolves to promote other agendas. The result is usually a backlash against wolves and, more insidiously, a damage to the perception of wolves and natural systems in the minds of their strongest supporters. Wolves are not fragile losers who need our every effort to help them survive. They and their societies are robust and adaptable. If we refrain from killing them and allow them some prey to eat, they will thrive."

Peterson, R., Professor, School of Forestry and Wood Products, Michigan Technological University: "Wolves might avoid corridors used heavily by snowmobiles. One might expect this to be especially important where wolves are hunted/trapped. I am aware of no evidence that this is true, but such evidence is not easily obtained. Such avoidance, if it occurs, might not be important to a local wolf population, depending on distribution and abundance of prey. On the other hand, it is just as likely that wolves would utilize snowmobile trails for travel routes. Whether that might be beneficial or harmful to their long-term persistence is another open question."

Thiel, D., Coordinator, Sandhill Outdoor Skills Center, Department of Natural Resources, Wisconsin: "As our Cessna plane circled 300 feet above the snowy forest, I witnessed three members of the radioed Boot-jack pack nonchalantly devouring a deer, while within 300 feet, 15 snowmobilers passed by on an established trail. The "kill" was actually an unretrieved kill made two months earlier by a deer hunter, which the wolves had dug up and salvaged. Far from being intrusive, snowmobiles are simply a part of the wolves' winter environment and wolves deal with them as the circumstances dictate."

Wydeven, A., Wildlife Technician, Department of Natural Resources, Wisconsin: "In Wisconsin, we don't feel that normal traffic along designated trails probably has much effect on wolves. Travel off trails and near den sites in late winter may be more of a problem. Snowmobile traffic should probably be evaluated in relationship to road access concerns; where road densities (including snowmobile trails) become too high (one mile of road per square mile of land), the ability of wolves to exist will decline."

463. Severinghaus, C. W.; and B. F. Tullar. WINTERING DEER VERSUS SNOWMOBILES. Conservationist; 29(6):31. 1975.
Potential and observed effects of snowmobiles on wintering deer are discussed. Studies are cited in which deer were observed fleeing from approaching snowmobiles from as far as three quarters of a mile. Energy expenditure calculations demonstrate the danger of snowmobile harassment to deer already hard-pressed by winter conditions. Snowmobiles should not be permitted in deer wintering areas, and established trails should be kept at least one half mile from such areas (Boyle and Samson 1983).

464. Shaffer, M. L. MINIMUM VIABLE POPULATIONS COPING WITH UNCERTAINTY. In: Viable Populations for Conservation, M. E. Soule, ed., pp. 69-86. Cambridge University Press, Cambridge. 1987.
Note: new.

465. Shaffer, M. L. POPULATION VIABILITY ANALYSIS. Conservation Biology 4(1):39-40. 1990.
Note: new.

466. Shaffer, M. L. POPULATION VIABILITY ANALYSIS. In: Challenges in Conservation of Biological Resources: A Practioner's Guide, D. Decker et al., eds., pp. 107-119. Westview Press, San Francisco, Calif. 1992.
Note: new.

467. Shea, D. S. A MANAGEMENT-ORIENTED STUDY OF BALD EAGLE CONCENTRATIONS IN GLACIER NATIONAL PARK. M.S. thesis; University of Montana, Missoula. 78 pp. 1973.
Observations of bald eagles congregating in Glacier National Park, Montana, revealed that the greatest threat to eagles in the park was disturbance caused by park visitors. Management recommendations include the protection of certain areas from visitor disturbance such as snowmobiling and boating, and the establishment of designated areas where viewing and photography can be managed (Boyle and Samson 1983).

468. Shea, R. E. ECOLOGY OF THE TRUMPETER SWAN IN YELLOWSTONE NATIONAL PARK AND VICINITY. M. S. thesis. Univ. of Montana. 132 pp. 1979.
Note: new.

469. Shoesmith, M. W. SEASONAL MOVEMENTS AND SOCIAL BEHAVIOR OF ELK ON MIRROR PLATEAU, YELLOWSTONE NATIONAL PARK. In: North American Elk: Ecology, Behavior and Management, M. S. Boyce and L. D. Hayden-Wing, eds., pp. 166-176. Univ. of Wyoming, Laramie. 1980.
Note: new.

470. Short, L. L. *HABITATS AND INTERACTIONS OF NORTH AMERICAN BLACK-BACKED WOODPECKERS. American Museum Novitates No. 2547:1-42. 1979.

471. Short, L. L. *HABITS AND INTERACTIONS OF NORTH AMERICAN THREE-TOED WOODPECKERS. American Museum Novitates No. 2547:1-42. 1979.

472. Short, L. L. *WOODPECKERS OF THE WORLD. Delaware Museum of Natural History, Greenville, DE. 676 pp. 1982.

473. Shult, M. J. AMERICAN BISON BEHAVIOR PATTERNS AT WIND CAVE NATIONAL PARK. Ph.D. Diss. Iowa State University, Ames. 191 pp. 1972.
Encounters with humans resulted in various responses by bison depending on the degree of harassment. Examples of possible effects of bison behavior on the American Indians of the Great Plains are presented (Boyle and Samson 1983).

474. Shultz, R. D.; and J. A. Bailey. RESPONSES OF NATIONAL PARK ELK TO HUMAN ACTIVITY. J. Wildl. Manage.; 42(1):91-100. 1978.
Responses of elk to human activities near a road were quantified for fall, winter and spring in Rocky Mountain National Park. These elk, which experienced little or no hunting, were not significantly disturbed by normal on-road visitor activities (Ream 1980),.

475. Sidhu, S. S.; and A. B. Case. A BIBLIOGRAPHY ON THE ENVIRONMENTAL IMPACT OF FOREST RESOURCE ROADS: A LIST. Newfoundland forest Research Centre, St. Johns, Info. Rep. N-X-149. 28 pp. 1977.
Bibliography.

476. Simberloff, D. and J. Cox. CONSEQUENCES AND COSTS OF CONSERVATION CORRIDORS. Conserv. Biol. 1:63-71. 1987.
Note: new.

477. Simberloff, D. and L. G. Abele. REFUGE DESIGN AND ISLAND BIOGEOGRAPHIC THEORY: EFFECTS OF FRAGMENTATION. Am. Nat. 120:41-50. 1987.
Note: new.

478. Singer, F. BEHAVIOR OF MOUNTAIN GOATS, ELK, AND OTHER WILDLIFE IN RELATION TO U.S. HIGHWAY 2, GLACIER NATIONAL PARK. Glacier National Park, West Glacier, MT. 96 pp. 1975.
Behavior, habitat use, and disturbance of elk, mountain goats, and other wildlife were studied in relation to a highway in Glacier National Park, Montana. Habituation to the highway made elk more vulnerable to poaching. Mountain goat-human interactions occurred frequently near a salt lick; goat reactions were avoidance of and/or flight from humans. Highway design and construction are discussed (Boyle and Samson 1983).

479. Singer, F. J. BEHAVIOR OF MOUNTAIN GOATS IN RELATION TO HIGHWAY 2, GLACIER NATIONAL PARK, MONTANA. J. Wildl. Manage.; 42(3):591-597. 1978.
A study was conducted in 1975 on mountain goats crossing a highway to visit a mineral lick in Glacier National Park, Montana. Collision hazards and high disturbance during crossings suggested that a goat crossing should be constructed and visitors should be restricted from the crossing area (Boyle and Samson 1983).

480. Singer, F. J. and J. B. Beattie. CONTROLLED TRAFFIC SYSTEM AND ASSOCIATED RESPONSES IN DENALI NATIONAL PARK. Arctic 39:195-203. 1986.
Note: new.
Moose were more alert to vehicle traffic than were caribou.

481. Singer, F. J. SOME PREDICTIONS CONCERNING A WOLF RECOVERY INTO YELLOWSTONE NATIONAL PARK: HOW WOLF RECOVERY MAY AFFECT PARK VISITORS, UNGULATES AND OTHER PREDATORS. Trans. N. Am. Wildl. Nat. Resour. Conf.; 57:567-583. 1991.

482. Skagen, S. K. BEHAVIORAL RESPONSES OF WINTERING BALD EAGLES TO HUMAN ACTIVITY ON THE SKAGIT RIVER, WASHINGTON. In: Proceedings of the Washington Bald Eagle Symposium, R. L. Knight et al., eds. The Nature Conservancy. 1980.
Note: new.

483. Skagen, S. K.; R. L. Knight; and G. H. Orians. HUMAN DISTURBANCE OF AN AVIAN SCAVENGING GUILD. Ecol. Appl.; 1:215-225. 1991.

484. Skiba, G. T. ECOLOGICAL EVALUATION OF THE DINOSAUR NATIONAL MONUMENT BIGHORN SHEEP HERD. M.S. thesis; Colorado State University, Fort Collins. 107 pp. 1981.
Human disturbance is one of several factors discussed relating to bighorn sheep ecology in Dinosaur National Monument, Colorado/Utah. An apparent sheep population decline has coincided with an increase in whitewater rafting through important sheep habitat, but observations suggest that sheep are not seriously disturbed by people on foot or in rafts. Management recommendations include considerations for location of campsites to minimize sheep disturbance (Boyle and Samson 1983).

485. Smith, A. T. and M. M. Peacock. CONSPECIFIC ATTRACTION AND THE DETERMINATION OF METAPOPULATION COLONIZATION RATES. Conservation Biology 4:320-323. 1990.
Note: new.
Recolonization of habitats after disturbance.

486. Snyder, H. A.; and N. F. R. Snyder. INCREASED MORTALITY OF COOPER'S HAWKS ACCUSTOMED TO MAN. Condor: 76:215-216. 1974.
Recovery patterns from 235 banded Cooper's hawk nestlings suggest that familiarity with man renders a hawk more likely to die from predation by man, especially shooting. Birds with frequent exposures to man from banding activities or observation from blinds were recovered more frequently after being killed by humans than birds with little exposure to man; such birds apparently have less fear of humans and are more vulnerable to human predation (Boyle and Samson 1983).

487. Soule, M. E. and D. Simberloff. WHAT DO GENETICS AND ECOLOGY TELL US ABOUT THE DESIGN OF NATURE RESERVES? Biol. Conservation 35:19-40. 1986.
Note: new.

488. Stace-Smith, R. MISUSE OF SNOWMOBILES AGAINST WILDLIFE IN CANADA. Nat. Can. 494):3-8. Ottawa. 1975.
Note: new.

489. Stalmaster, M. V. and J. A. Gessaman. ECOLOGICAL ENERGETICS AND FORAGING BEHAVIOR OF OVERWINTERING BALD EAGLES. Ecological Monographs 54:407-428. 1984.
Note: new.
High levels of human disturbance during winter could increase energy demands and result in increased mortality rates.

490. Stalmaster, M. V., J. K. Kaiser, and S. K. Skagen. EFFECTS OF RECREATIONAL ACTIVITY ON FEEDING BEHAVIOR OF WINTERING BALD EAGLES. J. Raptor Research 27(1):93. 1983.
Note: new.

491. Stalmaster, M. V.; and J. R. Newman. BEHAVIORAL RESPONSES OF WINTERING BALD EAGLES TO HUMAN ACTIVITY. J. Wildl. Manage.; 42(3):506-513. 1978.
Tolerance of wintering bald eagles in Washington to disturbance was determined by relating eagle distributions to human activity and measuring flight distances of eagles from simulated human disturbances. Human activity had adverse effects on eagle distribution and behavior. Management recommendations aimed at reducing human-caused disturbance are suggested (Boyle and Samson 1983).

492. Stalmaster, M. V.; and R. G. Plettner. DIETS AND FORAGING EFFECTIVENESS OF BALD EAGLES DURING EXTREME WINTER WEATHER IN NEBRASKA. J. Wildl. Manage.; 56(2):355-367. 1992.
The authors studied the diets and foraging efficiency of bald eagles on a system of reservoirs and canals adjacent to, and including a portion of, the Platte River System during extreme weather and extensive ice cover in southwestern Nebraska in 1989. Hunting, piracy, and scavenging comprised 87, 9, and 4% of 1,395 foraging attempts, respectively. Foraging opportunities and efficacy were enhanced by the maintenance of ice-free waters by hydroelectric and steam-plant operations, and by the disabling of prey by hydroelectric facilities. Adults were more effective foragers than subadults. The authors conclude that, with proper maintenance, power-generating facilities can benefit wintering eagles by providing foraging opportunities during periods of potential energy stress.

493. Stalmaster, M. V.; J. L. Kaiser and S. K. Skagen. EFFECTS OF RECREATIONAL ACTIVITY ON FEEDING BEHAVIOR OF WINTERING BALD EAGLES. J. Raptor Res.; 27(1):93. 1993.

494. Stankey, G. H., D. N. Cole, R. C. Lucas, M. E. Peterson, and S. S. Frissell. LIMITS OF ACCEPTABLE CHANGE (LAC) SYSTEM FOR WILDERNESS PLANNING. General Technical Report INT-176. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah. 1985.
Note: new.
Follows carrying capacity concepts (no set number of visitors). Sets quantifiable standards of impact levels that trigger management actions.

495. Stankey, G. H.; and D. W. Lime. RECREATIONAL CARRYING CAPACITY: AN ANNOTATED BIBLIOGRAPHY. USDA, U.S. For. Serv. Gen. Tech. Rep. INT-3. 45 pp. 1973.
*Annotated Bibliography.

496. Stemp, R. E. HEART RATE RESPONSES OF BIGHORN SHEEP TO ENVIRONMENTAL FACTORS AND HARASSMENT. M. S. Thesis, Univ. of Calgary, Alberta, Canada. 371 pp. 1983.
Note: new.

497. Stenzel. L. E.; H. R. Huber; and G. W. Page. *FEEDING BEHAVIOR AND DIET OF THE LONG-BILLED CURLEW AND WILLET. Wilson Bull.; 88:314-332. 1976.

498. Stephenson, R. O. CHARACTERISTICS OF WOLF DEN SITES. Alaska Dept. Fish Game Project W-017-R-06/WP14/J06/FIN. 29 pp. 1974.
Studies of wolf den site characteristics in the Brooks Range of Alaska and potential effects of human disturbance at den sites are discussed. Incidents of wolf-human interactions and factors important in determining wolf responses to humans are noted. It is suggested that in areas where wolves are shy of humans, prolonged human presence within 3.2 km of dens may affect wolf behavior and cause den abandonment (Boyle and Samson 1983).

499. Stevens, D. R. BIGHORN SHEEP MANAGEMENT IN ROCKY MOUNTAIN NATIONAL PARK. Proc. Bienn. Conf. North Am. Wild Sheep Goat Counc., 3. 1982.
One objective of bighorn sheep management in Rocky Mountain National Park, Colorado, has been to reduce the effects of park visitors on sheep. Visitor use of critical sheep habitats has been reduced by trail closures, and initial analysis indicates that disturbance of sheep has been reduced (Boyle and Samson 1983).

500. Stockwell, C. A., G. C. Bateman, and J. Berger. CONFLICTS IN NATIONAL PARKS: A CASE STUDY OF HELICOPTERS AND BIGHORN SHEEP TIME BUDGETS AT GRAND CANYON. Biological Conservation 56:317-328.
Note: new.
Frequent alerting affected food intake.

501. Storer, B. E. *ASPECTS OF THE BREEDING ECOLOGY OF THE PIGMY NUTHATCH AND THE FORAGING ECOLOGY OF WINTERING MIXED-SPECIES FLOCKS IN WESTERN MONTANA. M.S. thesis; Univ, Montana, Missoula. 1977.

502. Strickland, M. A.; C. A. Douglas; M. Novak; and N. P. Hunziger. *FISHER. Pages 586-598 in: J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: biology, management, and economics. John Hopkins Univ., Baltimore. 1982.

503. Strickland, M. A.; C. W. Douglas; M. Novak; and N. P. Hunziger. *MARTEN (MARTES AMERICANA). Pages 599-612 in: Wild mammals of North America: biology, management, and economics. The John Hopkins Univ. Press, Baltimore. 1982.

504. Sweeney, J. M. and J. R. Sweeney. SNOW DEPTHS INFLUENCING WINTER MOVEMENTS OF ELK. Jour. of Mammalogy 65(3):524-526. 1984.
Note: new.

505. Swenson, J. E. ECOLOGY OF THE BALD EAGLE AND OSPREY IN YELLOWSTONE NATIONAL PARK. M.S. thesis; Montana State University, Bozeman. 146 pp. 1975.
Relationships of bald eagles and ospreys to human disturbances were examined during studies in Yellowstone National Park. Ospreys nesting on Yellowstone Lake had significantly lower nest success and productivity per occupied nest than ospreys nesting along streams, and the difference appeared to be related to human disturbance. Bald eagle reproduction did not appear to be affected by human disturbance. Management recommendations are presented (Boyle and Samson 1983).

506. Swenson, J. E. FACTORS AFFECTING STATUS AND REPRODUCTION OF OSPREYS IN YELLOWSTONE NATIONAL PARK. J. Wildl. Manage.; 43:595-601. 1979.
Reproduction of ospreys in Yellowstone National Park was higher along streams with little human disturbance than on Yellowstone Lake, where humans were more concentrated. Reproduction at active nests more than 1 km from a backcountry campsite on Yellowstone Lake was comparable to that for nests near streams. Since undisturbed ospreys reproduced at a rate allowing population stability, the elimination of disturbance by visitor management should allow the declining lake population to stabilize (Boyle and Samson 1983).

507. Swenson, J. E.; K. L. Alt; and R. L. Eng. *THE ECOLOGY OF THE BALD EAGLE IN THE GREATER YELLOWSTONE ECOSYSTEM. Wildl. Monogr. 95. 46 pp. 1986.

508. Taylor, C. R., N. C. Heglund, and G. M. Maloiy. ENERGETICS AND MECHANICS OF TERRESTRIAL LOCOMOTION. Jour. Exp. Biol. 97:1-21. 1982.
Note: new.

509. Telfer, E. S. and J. P. Kelsall. STUDIES OF MORPHOLOGICAL PARAMETERS AFFECTING UNGULATE LOCOMOTION IN SNOW. Can. Jour. Zool. 57:2153-2159. 1982.
Note: new.

510. Temple, S. A. *SYSTEMATICS AND EVOLUTION OF THE NORTH AMERICAN MERLINS. Auk; 89:325-338. 1972.

511. Tennessee State University, Memphis. EFFECTS OF NOISE ON WILDLIFE AND OTHER ANIMALS. U.S. Govt. Printing Ofc., Washington, D.C. 74 pp. 1971.
Note: new.
Prepared for U.S. Ofc. of Noise Abatement and Control.

512. Tenpas, G. H. EFFECTS OF SNOWMOBILE TRAFFIC ON NON-FOREST VEGETATION. Lake Superior Biological Conference, Ashland, Wisc. 1972.
Note: new.

513. Theil, R. P. RELATIONSHIP BETWEEN ROAD DENSITIES AND WOLF HABITAT SUITABILITY IN WISCONSIN. Am. Midl. Nat.; 113:404-407. 1985.
Data on demise of wolf and increase in road densities compared between 1926 and 1960. Wolves failed to survive when road densities exceeded 0.93 miles/sq. mi.

514. Thelander, C. G. SPECIAL WILDLIFE INVESTIGATIONS: BALD EAGLE REPRODUCTION IN CALIFORNIA, 1972-1973. Calif. Dept. Fish Game Project W-054-R-06/WP02/J05/8A. 18 pp. 1973.
Human disturbances interfere with nest selection and occupancy of bald eagles in California, posing a major threat to the already endangered population. A territory in a recreation area used by boaters, campers, and off-road vehicles was abandoned by eagles in 1972, possibly due to human disturbance (Boyle and Samson 1983).

515. Thomas, J. W., ed. WILDLIFE HABITATS IN MANAGED FORESTS IN THE BLUE MOUNTAINS OF OREGON AND WASHINGTON. USDA Forest Service Handbook 553. 512 pp. 1979.
Note: new.
A most comprehensive study of deer and elk management. Provides tools for identifying cover and vegetation types. Quantifies impacts from management activities, including roads.

516. Thompson, R. W. POPULATION DYNAMICS, HABITAT UTILIZATION, RECREATIONAL IMPACTS AND TRAPPING OF INTRODUCED ROCKY MOUNTAIN GOATS IN THE EAGLE'S NEST WILDERNESS AREA, COLORADO. Proc. Bienn. Symp. North. Wild Sheep Counc.; 2:459-464. 1980.
Recreation impacts on mountain goats was assessed by simulating disturbances and observing goat-human interactions in Colorado. Flight distance of goats was greatest for nanny and sub-adult groups, and averaged 82.6 m for all groups. The typical flight intensity was a slow walk away from the human. It is concluded that recreational impacts on the goat population are slight (Boyle and Sampson 1983).

517. Thorne, T.; G. Butler; T. Varcalli; K. Becker; and S. Hayden-Wing. THE STATUS, MORTALITY, AND RESPONSE TO MANAGEMENT OF THE BIGHORN SHEEP OF WHISKEY MOUNTAIN. Wyo. Game Fish Dept., Game Fish Res. Lab. Wildl. Tech. Rep. 7. 213 pp. 1979.
Ecological aspects of bighorn sheep studied in Wyoming included responses of sheep to encounters with humans. Sheep responses to humans varied with sex, age, and activity of sheep, environmental factors, and the nature of the disturbance. All mountain recreationists may stress sheep they encounter; stress induced by such passive harassment might be the most serious consequence of man-sheep encounters. Management recommendations include control of human-sheep interactions (Boyle and Samson 1983).

518. Thorne, E. T., R. E. Dean, and W. G. Hepworth. NUTRITION DURING GESTATIONN IN RELATION TO SUCCESSFUL REPRODUCTION IN ELK. J. Wildl. Manage. 40:330-335. 1976.
Note: new.

519. Thurber, J. M.; R. O. Peterson; T. D. Drummer; and S. A. Thomasma. GRAY WOLF RESPONSE TO REFUGE BOUNDARIES AND ROADS IN ALASKA. Wildl. Soc. Bull.; 22:61-68. 1994.
The response of gray wolves to different road types and human presence at the boundaries of Kenai National Wildlife Refuge, Alaska, was examined in a study of radio-collared wolves in 1976-1979. Wolf activity within discrete distances up to 5 km from roads and boundaries were computed. Wolves avoided oilfield access roads open to public use, yet they were attracted to a gated pipeline access road and secondary gravel roads with limited human use. Wolf response to a major public highway was equivocal, perhaps because wolves used a den only 1 km away. There was no detectable difference in wolf use of land on either side of the eastern refuge boundary adjacent to national forest lands, but on the western, settled boundary wolves used refuge lands more than adjacent private land. The data presented in this study suggests that wolf absence from settled areas and some roads was caused by behavioral avoidance rather than direct attrition resulting from killing of animals.

520. Tibbs, A. L. SUMMER BEHAVIOR OF WHITE-TAILED DEER AND THE EFFECTS OF WEATHER. M.S. thesis; Pennsylvania State University, State College. 93 pp. 1967.
During research of summer behavior of white-tailed deer in Pennsylvania, responses of deer to the presence of the observer and various other disturbances were noted. The observer on a 20-foot high observation tower did not appear to significantly affect deer behavior. Deer response to disturbance was inversely related to its regularity (Boyle and Samson 1983).

521. Titus, J. R.; and L. W. van Druff. RESPONSES OF THE COMMON LOON TO RECREATIONAL PRESSURE IN BOUNDARY WATER CANOE AREA, NORTHEASTERN MINNESOTA. Wildl. Monogr.; 79:3-59. 1981.
Results are reported of a field study to evaluate the impact of outdoor recreationists on nesting and breeding success of the common loon in Minnesota. The authors conclude that that human use of the Boundary Waters Canoe Area slightly reduces the nesting and breeding success of loons in high impact areas, but since some loons are undisturbed and others habituate to human use the adult breeding population has not declined in the past 25 years (Boyle and Samson 1983).

522. Toweill, D. E.; and J. E. Tabor. *THE NORTHERN RIVER OTTER (LUTRA CANADENSIS) (SCHREBER). Pages 688-703 in: J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: biology, management, and economics. John Hopkins Univ. Press, Baltimore. 1982.

523. Tracy, D. M. REACTIONS OF WILDLIFE TO HUMAN ACTIVITY ALONG MOUNT McKINLEY NATIONAL PARK ROAD. M.S. thesis; University of Alaska, Fairbanks. 260 pp. 1977.
Reactions of 5 species of wildlife to human and vehicle activity on the park road in McKinley National Park were studied. Avoidance was observed for some bears, foxes, and possibly caribou; many other animals were attracted to the road. Of the ungulates studied, females with young were the most easily disturbed. Many animals appear habituated to human activities. Management recommendations based on the study are presented (Boyle and Samson 1983).

524. Trimble, S. A. *HABITAT MANAGMENT SERIES FOR UNIQUE OR ENDANGERED SPECIES-MERLIN. USDI, Bur. Land Manage. Tech. Note, Report No. 15, Denver. 41pp. 1975.

525. Tucker, P. ANNOTATED GRAY WOLF BIBLIOGRAPHY. USDI, U.S. Fish Wildl. Serv., Region 6, Denver, CO. 117 pp. 1988.
*Annotated Bibliography.

526. University of Wisconsin, Madison. EFFECTS OF SNOWMOBILE TRAFFIC ON NON-FOREST VEGETATION: SECOND REPORT. College of Agricultural and Life Sciences, Dept. of Agronomy, Univ. of Wisconsin, Madison. 1973.
Note: new.

527. U.S., Fish and Wildlife Service. *GRIZZLY BEAR RECOVERY PLAN. USDI, U.S. Fish Wildl. Ser., Washington, D.C. 199 pp. 1982.

528. U.S. Environmental Protection Agency. EFFECTS OF NOISE ON WILDLIFE AND OTHER ANIMALS. U.S. Environ. Prot. Agency, Off. Noise Abatement. Control NTID300.5. 74 pp. 1971.
Demonstrated and suspected effects of noise on wildlife and domestic animals are reviewed in this comprehensive report. Sources of noise potentially disturbing to wildlife include industries, automobiles, aircraft, and recreational vehicles (Boyle and Samson 1983).
529. U.S. Fish and Wildlife Service. *BALD EAGLE MANAGEMENT GUIDELINES OREGON-WASHINGTON. USDI; Fish and Wildlife Service, Portland Area Office, Oregon. 10pp. 1981.
530. U.S. Fish and Wildlife Service. *NORTHERN ROCKY MOUNTAIN WOLF RECOVERY PLAN. USDI, U.S. Fish Wildl. Ser., Denver. 119 pp. 1987.
531. U.S. Fish and Wildlife Service. *WHOOPING CRANE RECOVERY PLAN. U.S. Fish Wildl. Serv., Albuquerque. 283 pp. 1986.
532. USDI, U.S. Fish and Wildlife Service. GUIDELINES FOR THE MANAGEMENT OF THE AMERICAN WHITE PELICAN, WESTERN POPULATION. U.S. Fish Wildl. Ser. Unpub. ms. 44 pp. 1984.
533. USDI, U.S. National Park Service. PUBLIC USE AND RECREATION; VEHICLES AND TRAFFIC SAFETY. Federal Register 38. Feb. 14, 1973:4405-4407. 1973.
Note: new.
534. USDI, U.S. Fish and Wildlife Service. THE REINTRODUCTION OF GRAY WOLVES TO YELLOWSTONE NATIONAL PARK. U.S. Fish Wildl. Ser., Draft Environmental Impact Statement, Helena, MT. 1993.
535. USDI, U.S. National Park Service. STATEMENT FOR MANAGEMENT-GRAND TETON NATIONAL PARK. U.S. National Park Service. 1985.
536. USDI, U.S. Fish and Wildlife Service. *WHITE-FACED IBIS: MANAGEMENT GUIDELINES, GREAT BASIN POPULATION. U.S. Fish Wildl. Ser., Portland, OR. 31 pp. 1985.
537. USDI, U.S. National Park Service. WINTER USE PLAN ENVIRONMENTAL ASSESSMENT, YELLOWSTONE AND GRAND TETON NANTIONAL PARKS AND JOHN D. ROCKEFELLER, JR., MEMORIAL PARKWAY, WYOMING, IDAHO, AND MONTANA. 114 pp. 1990.
Note: new.
538. VanDyke, F. G., R. H. Brocke, H. G. Shaw, B. B. Ackerman, T. P. Hemker, and F. G. Lindzey. REACTIONS OF MOUNTAIN LIONS TO LOGGING AND HUMAN ACTIVITY. J. Wildl. Manage. 50:95-102. 1986.
Note: new.
539. Vaske, J. J., D. J. Decker, and M. J. Manfredo. HUMAN DIMENSIONS AND WILDLIFE MANAGEMENT: AN INTEGRATED FRAMEWORK FOR COEXISTENCE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 33-49. Island Press. Washington, D.C. 1995.
Note: new.

540. Vaske, J. J., A. R. Graefe, and F. R. Kuss. RECREATION IMPACTS: A SYNTHESIS OF ECOLOGICAL AND SOCIAL RESEARCH. Trans. North Amer. Wildl. and Nat. Resour. Conf. 48:96-107. 1983.
Note: new.

541. Vermeer, K. SOME ASPECTS OF THE NESTING REQUIREMENTS OF COMMON LOONS IN ALBERTA. Wilson Bull.; 85:429-435. 1973.
A significant correlation was found between number of breeding loons and the amount of human disturbance occurring at lakes. It is suggested that because loons appear to be intolerant of human disturbance they may serve as indicators of the wilderness qualities of lakes (Boyle and Samson 1983).

542. Wagar, J.V.K. RECREATION AND WILDLIFE PROBLEMS OF THE CENTRAL ROCKY MOUNTAINS. J. For.; 52:186-190. 1954.
Recreation based on wildlife resources in the central Rocky Mountains is discussed in terms of noneconomic value to participants. Problems such as value mesuration, financing of research, land ownership, and need for development are discussed (Boyle and Samson 1983).

543. Wall, G.; and C. Wright. THE ENVIRONMENTAL IMPACT OF OUTDOOR RECREATION. Univ. Waterloo, Ontarion, Dept. Geogr. Publ. Ser. 11. 69 pp. 1977.
A comprehensive review of environmental impacts of outdoor recreation is presented, including a chapter on wildlife impacts. Sections describe disturbance of wildlife, loss and gain of habitats, and changes in populations and species composition. The nature and scope of research on wildlife impacts are critically evaluated (Boyle and Samson 1983).

544. Wall, J. H. IMPACTS OF OUTDOOR RECREATION ON THE ENVIRONMENT. Council of Planning Librarians, Monticello, Ill., Exch. Bibliog. 1363. 19 pp. 1977.
Bibliography.

545. Wallace, G. N. VISITOR MANAGEMENT: LESSONS FROM GALAPAGOS NATIONAL PARK. In: Ecotourism: A Guide for Planners and Managers, K. Lindberg and D. E. Hawkins, eds., pp.55-81. The Ecotourism Society. North Bennington, Vermont. 1993.
Note: new.

546. Wallen, R. L. *ANNUAL BROOD SURVEY FOR HARLEQUIN DUCKS IN GRAND TETON NATIONAL PARK. Grand Teton National Park Resource Management files, Moose, WY. 15 pp. 1987.

547. Wallen, R. L. *HABITAT UTILIZATION OF HARLEQUIN DUCKS IN GRAND TETON NATIONAL PARK. M.S. thesis; Montana State University, Bozeman. 67 pp. 1987.

548. Wallen, R. L.; and C. R. Groves. *STATUS AND DISTRIBUTION OF HARLEQUIN DUCKS IN NORTHERN IDAHO. Unpublished Report, Idaho Dept. of Fish and Game, Boise. 34 pp. 1988.

549. Wallis, C. A.; and C. R. Wershler. *STATUS AND BREEDING OF MOUNTAINS PLOVERS IN CANADA. Can. Field-Nat.; 95:133-136. 1981.

550. Walter, H. and K. L. Garrett. EFFECTS OF HUMAN ACTIVITY ON WINTERING BALD EAGLES IN THE BIG BEAR VALLEY, CALIFORNIA. FINAL REPORT. USDA Forest Service, Big Bear District, Fawnskin, Calif. 79 pp. 1981.
Note: new.
Snow machines and ATVs are especially disturbing, probably due to association with random movement, loud noise, and operators are generally exposed.

551. Walter, H. IMPACT OF HUMAN ACTIVITY ON WILDLIFE. Pages 241-262 in: K. A. Hammond, C. Macinko, and W. B. Fairchild, eds. Sourcebook on the environment: A guide to the literature. University of Chicago Press, Chicago, Ill. 1978.
Literature concerning human impacts on wildlife is reviewed. Effects of human population expansion and utilization of energy and resources are emphasized, but nonconsumptive uses are also mentioned. Sections discuss general surveys, attitudes toward wildlife, changes in wildlife population levels, species diversity, and wildlife conservation, among others (Boyle and Samson 1983).

552. Wanek, W. J. and L. H. Schumacher. A CONTINUING STUDY OF THE ECOLOGICAL IMPACT OF SNOWMOBILING IN NORTHERN MINNESOTA. FINAL REPORT FOR 1974-1975. State College, Bemidji, Minn. 1975.
Note: new.

553. Wanek, W. J. ECOLOGICAL IMPACT ON VEGETATION AND SOIL MICROBES. In: Snowmobile and Off the Road Vehicle Research Symposium Proceedings. Recreation Resour., Michigan State Univ. 1973.
Note: new.

554. Wanek, W. J. SNOWMOBILING IMPACT ON VEGETATOIN, TEMPERATURES AND SOIL MICROBES. In: Snowmobile and Off the Road Vehicle Research Symposium Proceedings, pp. 117-130. 1971.
Note: new.

555. Ward, A. L. EFFECTS OF HIGHWAY CONSTRUCTION AND USE ON BIG GAME POPULATIONS. Fed. Highway Ofc. Res. and Dev. Rep. FHWA-RD-76-174. Nat. Tech. Inf. Serv., Springfield, Va. 92 pp. 1976.
Note: new.

556. Ward, A. L. TELEMETERED HEART RATE OF THREE ELK AS AFFECTED BY ACTIVITY AND HUMAN DISTURBANCES. In: Proceedings of Symposium: Dispersed Recreation and Natural Resource Management. Utah State Univ. 1977.
Note: new.
Two cow elk and a spike. Positive correlation to man-caused disturbance and elevated heart rates. Highest incidence occurred with loud noises and direct interaction.

557. Ward, A. L. and J. J. Cupal. TELEMETERED HEART RATE OF THREE ELK AS AFFECTED BY ACTIVITY AND HUMAN DISTURBANCE. Rocky Mt. Forest and Range Exper. Sta., Laramie, Wyo. 1980.
Note: new.

558. Ward, A. L.; J. J. Cupal; A. L. Lea; C. A. Oakley; and R. W. Weeks. ELK BEHAVIOR IN RELATION TO CATTLE GRAZING, FOREST RECREATION, AND TRAFFIC. Proc. N. Am. Wildl. Conf.; 38:327-337. 1973.
Telemetered elk in Wyoming study area preferred to be one-half mile distance from people who were camping, picnicking, and fishing. Suggests that in planning recreation facilities in elk habitat, people concentration areas should be one-half mile from elk feeding sites and provide adequate cover buffer zones (Ream 1980).
559. Warren, H. V. and R. E. Delavault, cited in H. L. Cannon and J. M. Bowles. CONTAMINATION OF VEGETATION BY TETRAETHYL LEAD. Science 137:765-766.
Note: new.
560. Watson, A. BIRD AND MAMMAL NUMBERS IN RELATION TO HUMAN IMPACT AT SKI LIFTS ON SCOTTISH HILLS. Jour. of Applied Ecology 16:753-754. 1979.
Note: new.
561. Weaver, J. L.; R. E. F. Escano; and D. S. Winn. A FRAMEWORK FOR ASSESSING CUMULATIVE EFFECTS ON GRIZZLY BEARS. Trans. N. Am. Wildl. and Nat. Resour. Conf.; 52:364-376. 1987.
562. Webb, R. H.; and H. G. Wilshire. AN ANNOTATED BIBLIOGRAPHY OF THE EFFECTS OF OFF-ROAD VEHICLES ON THE ENVIRONMENT. U.S. Geol. Surv. Open File Rep. 78-149. 15 pp. 1978.
Annotated Bibliography.
563. Weedin, R. NONCONSUMPTIVE USERS: A MYTH. Alaska Conserv. Rev.; 17(3):3,15. 1976.
Several examples of adverse impacts on wildlife from recreationists and scientists are cited to support the contention that nonconsumptive users of wildlife do not exist (Boyle and Samson 1983).
564. Werschkul, D. F.; E. McMahon; and M. Leitschuh. SOME EFFECTS OF HUMAN ACTIVITIES ON THE GREAT BLUE HERON IN OREGON. Wilson Bull.; 88:660-662. 1976.
565. Whelan, T. ed. NATURE TOURISM: MANAGING FOR THE ENVIRONMENT. Island Press, Washington, D.C. 1991.
Note: new.
566. White, P. S. and S. P. Bratton. AFTER PRESERVATION; PHILOSOPHICAL AND PRACTICAL PROBLEMS OF CHANGE. Biol. Conservation 18:241-255. 1980.
Note: new.
It is not only the recreationist who impacts wildlands, but the scientist, educator, and school group as well.
567. White, R. P. *DISTRIBUTION AND HABITAT PREFERENCE OF THE UPLAND SANDPIPER IN WISCONSIN. Amer. Birds; 37:16-22. 1983.
568. Whittaker, J. SNOWMOBILING OVER FORAGE GRASSES. Paper presented at Conference on Snowmobiles and All-terrain Vehicles at Univ. of Western Ontario, Canada. 1971.
Note: new.
569. Wiens, J. A. SPATIAL SCALING IN ECOLOGY. Functional Ecology 3:385-397. 1989.
Note: new.

570. Wilcox, B. A. and D. D. Murphy. CONSERVATION STRATEGY: THE EFFECTS OF FRAGMENTATION ON EXTINCTION. Am. Nat. 125:879-887.
Note: new.
571. Wilinson, T. GREATER YELLOWSTONE NATIONAL FORESTS. Falcon Press, Helena. 104 pp. 1991.
572. Wilkes, B. THE MYTH OF THE NONCONSUMPTIVE USER. Can. Field-Nat.; 91:343-349. 1977.
The concept that some outdoor recreational activities are nonconsumptive of the resource base is examined and rejected. Impacts of such on vegetation, wildlife, and the quality of the environment are noted. User restrictions, a proposed theory for non-use planning, and justification for landscape preservation are discussed (Boyle and Samson 1983).
573. Wilkinson. P. F. ENVIRONMENTAL IMPACT OF OUTDOOR RECREATION AND TOURISM: A BIBLIOGRAPHY. Vance Bibliographies, Monticello, Ill., Publ. Admin. Ser. Bibliogr. P-57. 90 pp. 1978.
*Bibliography.
574. Williams, M. and A. Lester. ANNOTATED BIBLIOGRAPHY OF OHV AND OTHER RECREATIONAL IMPACTS TO WILDLIFE. Eldorado National Forest. USDA Forest Service, Pacific Southwest Region. 10 pp. 1996.
Note: new.
575. Wilmore, S. B. *SWANS OF THE WORLD. Taplinger Publ., New York. 229 pp. 1974.
576. Wilson, D. E. *WOLVERINE. Pages 644-652 in: J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: biology, management, and economics. John Hopkins Univ. Press, Baltimore. 1982.
577. Wilson, L. O. THE FORGOTTEN DESERT BIGHORN HABITAT REQUIREMENT. Trans. Desert Bighorn Counc.; 13:108-113. 1969.
An important but often-neglected habitat requirement of bighorn sheep is space. A review of the literature shows that bighorn are generally intolerant of human disturbance. Management of developments, livestock grazing, other ungulates, and recreational activities should take into account adverse effects of these activities on bighorn sheep (Boyle and Samson 1983).
578. Witmer, G. W. and D. S. deCalesta. EFFECT OF FOREST ROADS ON HABITAT USED BY ROOSEVELT ELK. Northwest Science 59(2):122-124. 1985.
Note: new.
Six females monitored for one year. Human activity on forest roads alters distributions of elk habitat use. Impact may be mitigated by road closures, especially during rutting and calving seasons.
579. Woodworth, C. G.; G. P. Bell; and M. B. Fenton. *OBSERVATIONS ON THE ECHOLOCATION, FEEDING BEHAVIOR AND HABITAT USE OF EUDERMA MACULATUM IN SOUTH CENTRAL BRITISH COLUMBIA. Can. J. Zool.; 59:1099-1102. 1981.
580. Wyoming Game and Fish Department. A STRATEGIC PLAN FOR THE COMPREHENSIVE MANAGEMENT OF WILDLIFE IN WYOMING. Wyoming Game and Fish Department, Cheyenne. 1990.

581. Yalden, D. W.; and P. E. Yalden. THE SENSITIVITY OF BREEDING GOLDEN PLOVERS, PLUVIALIS APRICARIA, TO HUMAN INTRUDERS. Bird Study; 36:49-55. 1989.

582. Yarmoloy, C.; M. Bayer; and V. Geist. BEHAVIOR RESPONSES AND REPRODUCTION OF MULE DEER DOES FOLLOWING EXPERIMENTAL HARASSMENT WITH AN ALL-TERRAIN VEHICLE. Canadian Field-Nat.; 102(3):425-429. 1988.
Five mule deer does were caught by helicopter and net gun and were equipped with radio collars. They were habituated to an all-terrain Vehicle (ATV) travelling the same truck trail for 12 weeks. Three of the females were then followed by ATV for 9 minutes per day for 15 days between 1 to 24 October, 1981, for a total of 135 minutes. The harassed females, but not the other females, shifted feeding into darkness, used cover more frequently, left their home ranges more often, and increased flight distance from the ATV. In the following year the three harassed females collectively raised 1 fawn, having had normal reproduction the year before and the year after. Neither the unmarked females in the study area nor the two radio-collared control females suffered decreases in reproduction during the study. these results confirm expectations and are statistically significant.

583. Young, D.; and J. Beecham. *BLACK BEAR HABITAT USE AT PRIEST LAKE, IDAHO. Pages 73-80 in: Bears: their biology and management. Int. Conf. on Bear Res. and Manage., vol 6. 1983.

584. Young, J. and A. Boyce. RECREATIONAL USES OF SNOW AND ICE IN MICHIGAN AND SOME OF ITS EFFECTS ON WILDLIFE AND PEOPLE. In: Proceedings of the Snow and Ice Symposium. Iowa Coop. Wildl. Res. Unit, Iowa State Univ., Ames. 820 pp. 1971.
Note: new.
Includes skiing.

585. Young, S. P. *THE BOBCAT OF NORTH AMERICA. The Stackpole Co., Harrisburg, PA. 193. 1958.

586. Zarn, M. *HABITAT MANAGEMENT FOR UNIQUE OR ENDANGERED SPECIES-BURROWING OWL. USDI, Bur. Land Manage. Tech. Note T-N-250, Rep. No. 11, Denver. 25 pp. 1974.

ADDENDUM

Anonymous. 1992. News and notes. Yellowstone Science, Yellowstone National Park, Wyo. 21 pp.

———. 1996a. Yellowstone Center for Resources 1995 Annual Report, S. Consolo Murphy, M.A. Franke, and S. Broadbent, eds., Yellowstone Park, Wyo. 82 pp.

———. 1996b. Investigators' Annual Reports for 1995, B. Lindstrom and S. Broadbent, eds., Yellowstone Park, Wyo. 134 pp.

Barnes, V.G., Jr. and O.E. Bray. 1967. Final report: Population characteristics and activities of black bear in Yellowstone National Park. Colo. Coop. Wildl. Research Unit, Colo. State Univ., Fort Collins. 199 pp.

Beall, R.C. 1974. Winter habitat selection and use by a western Montana elk herd. Ph.D. Thesis. Univ. of Montana, Missoula. 197 pp.

Cole, G.F. 1972. Grizzly bear–elk relationships in Yellowstone National Park. J. Wildl. Manage. 36(2):556–570.

DelGuidice, G., F.J. Singer, U.S. Seal, and G. Bowser. 1994. Physiological responses of Yellowstone bison to winter nutritional deprivation. J. Wildl. Manage. 58(1):24–34.

Goodrich, J.M. and J. Berger. 1994. Winter recreation and hibernating black bears (*Ursus americanus)*. Biological Conservation 67:105–110.

Green, G.I. 1988. Dynamics of ungulate carcass availability and use by bears on the northern range and Firehole and Gibbon drainages. Yellowstone Grizzly Bear Investigations: Annual Report of the Interagency Bear Study Team, R.R. Knight, B.M. Blanchard, and M. Mattson, eds., U.S. National Park Service, Bozeman, Mont.

Mattson, D.J. and J. Henry. 1987. Spring grizzly bear use of ungulate carcasses in the Firehole River drainage: Second Year Progress Report. Pp. 63–72 in Yellowstone Grizzly Bear Investigations: Annual Report of the Interagency Study Team 1986. USDI National Park Service. Bozeman, Mont.

Wesley, D.E., K.L. Knox, and J.G. Nagy. 1973. Energy metabolism of pronghorn antelope. J. Wildl. Manage. 57:563–573.

Appendix III

MATRIX OF WINTER RECREATION EFFECTS ON WILDLIFE

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Yellowstone Park, Wyoming

March 1997

Index:

SNOWMOBILING

Bald Eagles

— "Since bald eagles apparently require freedom from human disturbance during the early stages of nesting. . . no habitat alterations, especially campgrounds, campsites or trails, should be made within 1 to 2km of a bald eagles nest" (Swensen 1975:121).

— in Grand Teton National Park, in reference to the RKO bald eagle nesting territory, "at the time of nest initiation there is still ample snow for snowmobiling on the plateau adjacent to the territory. This activity at or above the level of the nest could be inhibiting nest initiation or disrupting incubation during the early stages: (p. 64); recommended that a buffer zone of "1 km or any reasonable distance deemed necessary to minimize any possible disturbance by snowmobiles (p. 80); observed adults in close association with three territories along the Snake River on the earliest eagle observation flight (Feb. 26, 1979) (Harmata 1996).

— in Greater Yellowstone, bald eagles will persist only if there is "adequate habitat available to avoid humans" and management of wintering and migration habitat also should be considered (p. iv); "Eagles shifted their activity patterns to periods when their presence would be least obvious to humans: very early morning and evening" (p. 13); "Snowmachines and all terrain vehicles are especially disturbing, probably due to associated random movement, loud noise and operators are generally exposed . . ." (p. 12); The cumulative effects of many seemingly insignificant or sequential (human) activities may result in disruption of normal behavior of wildlife. "The importance and pertinence to bald eagle behavior cannot be overstated." (p. 14) (Harmata 1996).

— "Sensitivity of nesting bald eagles to human activity generally diminishes in the following temporal order: nest site selection>nest building>egg laying>incubation>brooding> fledging" (p. 37). This indicates that disturbance in winter may be influential nesting chronology, since nest site selection occurs "year round", nest building occurs "October through April" and egg-laying occurs "28 February through 10 April" (p. 37) in the Greater Yellowstone area (Harmata 1996).

— in Glacier National Park, the greatest threat to bald eagles was human disturbance; certain areas should be protected from snowmobiling (Shea 1975) (M.S. Thesis).

— in Grand Teton Park, snowmobiling could be inhibiting nest initiation or disrupting incubation at the RKO bald eagle nesting territory and a recommended buffer zone of "1km or any reasonable distance deemed necessary to minimize any possible disturbance by snowmobiles." During investigators first flight in 1979 on Feb. 26, adult eagles were observed in close association with 3 territories along the Snake River (Alt 1980:80) (M.S. Thesis).

— human disturbance of an avian scavenger guild, includes bald eagles (Skagen et al. 1991).

— in Yellowstone and Grand Teton Parks, bald eagles reside year-round. "Resident bald eagles begin defending territories in late January, display courtship in February, and begin laying eggs and incubating in March. They are sensitive to disturbance by humans from late winter through spring and early summer. Wintering bald eagles depend on three major types of food: waterfowl, carrion, and fish. . . .About 20-40 bald eagles, including 14 nesting pairs spend part of the winter in Yellowstone: (USDI National Park Service 1990:12).

Bears

— a grizzly bear den was abandoned after snowmobile disturbance (Jonkel 1980).

— in Yellowstone Park, black bears began denning between late October and mid-November. The winter dormancy period terminated primarily between late March and the end of April (Barnes and Bray 1967).

— in Yellowstone Park's Firehole, Madison and Gibbon River drainages, grizzly bears emerged from hibernation and traveled to elk and other native ungulate winter areas between March and early May (Cole 1972).

— in Grand Teton and Yellowstone Parks, "Bears usually emerge from dens in mid-March, but they may emerge earlier depending on elevation, slope, aspect, weather conditions, and the individual bear's age, sex, condition and behavioral patterns. . .The late winter to early spring period is a crucial feeding time. . .winter-killed carrion. . .is an important source of protein. . .bears. . .must feed undisturbed in preferred areas to meet nutritional requirements. . .Adult females and young grizzlies, especially, need carrion and suffer most from its exclusion for their diet. . .When adult females are excluded on a regular basis from carrion sources, higher mortality and lower fecundity rates can be expected" (USDI National Park Service 1990:15).

Bighorn Sheep

— on winter range, may be debilitating to winter-stressed sheep (Berwick 1968) (M.S. Thesis).

— heart rates of unrestrained bighorn sheep varied inversely with distance from a road, in Alberta (MacArthur et al. 1979).

— cardiac and behavioral responses of bighorn sheep to human disturbance (MacArthur et al. 1982).

Bison

— in Yellowstone Park, snow packed roads used for winter recreation in the interior of the park appeared to be the major influence in major changes in bison numbers and distribution in the park, in the past decade. Roads provided energy-efficient travel that resulted in energy saving within traditional foraging areas, range expansion, major shifts among previously semi-isolated subpopulations, and a mitigation of winterkill and enhancement of calf survival. Effects will ultimately occur on an ecosystem level (Meagher 1993).

— in Yellowstone Park, "Bison were frequently observed traveling in the packed and groomed snowmobile trail and habitually used the trail as part of their intricate network of trails during the winter months" (Aune 1981:34).

Elk

— in Yellowstone Park, resulted in average flight distance of 33.8 m (Aune 1981) (M.S. Thesis).

— in Montana, additional stress from snowmobiles in winter is undesirable (Aasheim 1980).

— in Idaho, road closures allowed elk to remain longer in preferred areas (Irwin and Peek 1979).

— forest roads evoke an avoidance response by elk (Lyon 1983).

— in Rocky Mountain Park, quantified responses of elk to human activities, in winter; non-hunted elk were not significantly affected by on-road visitor activities (Schultz and Bailey 1978).

Mule Deer

— after habituating to an all-terrain vehicle (ATV) for 12 weeks, harassment of radio-collared females by the ATV altered feeding, altered spatial use, and decreased production of young the following year (Yarmaloy 1988).

— elicited motor responses (in sagebrush winter range) when closer than 133m; moved at similar velocities when disturbed by snowmobiles or persons afoot; moved shorter horizontal distance when disturbed by snowmobiles than when disturbed by persons afoot; became <u>more</u> sensitive in moving away from disturbances, as the controlled trials progressed. Test disturbances did not prevent adult females from producing fawns later that year. (See Freddy et al. 1966 in "SNOWSHOEING" section.) (Used 18 radio-collared adult females, Colorado.) (Freddy et al. 1966).

— in Yellowstone Park, resulted in average flight distance of 28.6m (Aune 1981).

— recommended that snowmobiles remain more than 470m from mule deer, in winter, in Colorado (Freddy et al. 1986).

White-tailed Deer

— altered spatial rise, Minnesota (Dorrance 1975).

— increased home-range sizes, Minnesota (Dorrance 1975).

— displaced animals from the vicinity of snowmobile trails, Minnesota (Dorrance 1975).

— routing snowmobile trails away from deer concentration areas was suggested (Eckstein et al. 1979).

— appeared to force deer into less-preferred habitats where nighttime radiant heat loss was increased, Wisconsin (Huff and Savage 1972).

— reduced home-range sizes, Wisconsin (Huff and Savage 1972).

— was detrimental to energy-conserving behavioral adaptations for winter survival, Minnesota (Moen 1978).

— provided trails that deer used, probably reducing energy expenditures, Maine (Richens and Lavigne 1978).

— caused energy expenditures to deer in wintering areas, expenditures calculated, New York (Severinghaus and Tullar 1975).

— effects on distribution in south-central Minnesota (Kopischke 1972).

— snowmobile trails enhanced deer mobility and probably reduced deer energy expenditures; snowmobile disturbance did not cause abandonment of preferred bedding and feeding sites, caused deer responses varying from running out of sight to remaining in place (Lavigne 1976) (M.S. Thesis).

— in responses to snowmobile activity, were more pronounced in a hunted than in an unhunted population of deer (Dorrance et al. 1975).

— established snowmobile trails should be kept at least one-half mile from white-tailed deer wintering areas, in New York (Severinghaus and Tullar 1975).

Trumpeter Swans

— in Yellowstone Park "No future activities should be planned which would increase human use of the north shore of Yellowstone Lake and the Yellowstone River from Fishing Bridge to Alum Creek after 20 October." At the time of her study, up to 100 trumpeters wintered in Yellowstone, although numbers were usually much lower (p. 109); "Land management agencies should direct human activities away from wintering and nesting sites. . .Winter activities such as snowmobiling or cross-country skiing will cause most swans to fly if the person can be seen. Snowmobile and ski trails should be routed away from the river courses" (Shea 1979:111) (M.S. Thesis).

Subnivian Mammals/Small Mammals

— increased mortality in small mammals beneath snow-packed trails; snow compaction by snowmobiles resulted in destruction of air spaces, reduced snow depth, increased snow density and increased thermal conductivity. Also a possibility of toxic air trapped in snow (4% carbon dioxide); destruction of wintering of small mammals at even conservative levels of snowmobile use (mammals trapped in the study: meadow vole, short-tailed shrew, white-footed mouse, ground squirrel and spotted skunk), Minnesota (Jarvinen and Schmid 1971).

— discusses possible effects on small mammals (Aasheim 1980).

— snowmobile compaction of snow changes the physical and thermal properties and potentially affects animals that live beneath the snow in winter (Corbet 1970).

— effects on small mammals (Bury 1978).

— in Minnesota, studied snowmobile use and winter mortality; used traps; meadow vole, short-tailed shrew, white-footed mouse, ground squirrel, masked shrew, spotted skunk, showed increased mortality of small mammals; destroyed subnivian air space, possibly trapped toxic air in snow. Even conservative levels of snowmobiling on trails is destructive to wintering small mammals (Jarvinen and Schmidt 1971; Schmidt 19971, Schmidt 1972).

— snowmobile use affected snowshoe hare and red fox mobility and distribution, in Ontario, mainly within 76 meters of snowmobile trail; hares avoid snowmobile trails, foxes use them (Neumann and Merriam 1973).

— discussed impacts of snowmobiles on the subnivian environment (Pruitt 1971).

Terrestrial Invertebrates

— preliminary studies of snowmobile compaction on invertebrates (Marshall 1972).

Fish

—— ability to swim diminished by snowmobile exhaust (lab and field studies on fingerling brook trout) (Adams 1975).

—— Baldwin, M.F. 1968

—— Bury, R.C. 1978.

—— polluted snow effects on freshwater and aquatic organisms (Hagen and Langeland 1973).

—— effects of snowmobiles on fish resources (Doan 1970).

—— "fish stop swimming in response to ground or sound vibrations" (Gabrielson and Smith 1995:100).

—— detection and reaction of fish to infrasound (Enger et al. 1993).

General

—— a literature review of wildlife harassment by snowmobiles. Documents Congressional testimony on impacts of snowmobiles on wildlife and recommends the prohibition of snowmobiles in national parks (Baldwin and Stoddard 1973).

—— in Ontario, snowmobiles caused significant changes in wildlife behavior; snowshoe hares and red foxes were disturbed mainly within 76 meters of the snowmobile trail; hares avoided snowmobiles trails, foxes used them (Neumann and Merriam 1972).

—— motorized recreational activities are generally much more destructive than nonmotorized activities (p. 194); "the indirect impacts of recreation on wildlife are clearly substantial but even more poorly understood than the direct impacts: (p. 196) (Cole and Landres 1995).

—— lead contamination associated with snowmobile trails (Collins and Snell 1982).

—— contamination of vegetation by tetraethyl lead (Cammon and Bowles 1962).

—— cites snowmobile harassment of ungulates (Curtis 1974).

—— effects on large mammals, medium-sized mammals, small mammals (Bury 1978).

—— effects on fish and wildlife resources (Doan 1970).

— "When people intrude into wildlife habitat, stress on wildlife populations is one result. Snowmobile activity is a particular problem as people move into wintering areas where animals may already be stressed" (Anderson 1995:163).

SNOWSHOEING/HIKING

Bears

— grizzlies do not actively defend dens from humans (Craighead and Craighead 1972).

Bighorn Sheep

— in California, protection of bighorn sheep includes regulation of hiking and sightseeing (DeMarchi 1975).

— in California, hikers did not appear to be adversely affecting sheep on Mount Baxter; if numbers of hikers increase, effects should be monitored (Elder 1977).

— minimizing harassment of sheep should be given top priority among management objectives (Horejisi 1976).

— in Rocky Mountain Park, visitor use of critical bighorn sheep habitats has been reduced by trail closures (Stevens 1982).

— impacts of hiking on Desert Bighorns (Graham 1980).

— in Colorado, hiking influences bighorn sheep distributions and activities (Bear and Jones 1973).

Birds

— see entry for Bald Eagles (Stalmaster and Newman 1978) of this report in section "Stress Induced by Human Activity. . ."

— how close certain passerine bird species will tolerate an approaching human (Cooke 1980).

— in Colorado, in winter, measured flushing responses and distances of American kestrels, merlins, prairie falcons, rough-legged hawks, ferruginous hawks, and golden eagles, when disturbed by humans walking or by vehicles. Walking disturbances resulted in more flushes than vehicle disturbances for all but prairie falcons (Holmes et al. 1983).

Elk

- in Rocky Mountain Park, elk made greater use of areas near roads as the winter-spring study progressed. People approaching animals off-roads usually caused elk to leave open areas; elk exhibited longer flight distances from an approaching person than from an approaching vehicle (Schultz and Bailey 1978).

- in Rocky Mountain Park, snowshoers and hikers occasionally disturbed elk along trails; did not quantify elk reactions; larger herds had greater flight distances (p.36); deep snow, blowing snow, and falling snow were frequently associated with shorter flight distances (p. 45) (Schultz 1975) (M.S. Thesis).

- on Colorado winter ranges, deer and elk avoided areas near roads, particularly areas within 200 meters of roads; deer avoided even dirt roads, some of which were used by hikers (Rost 1975) (M.S. Thesis).

Moose

- in Wyoming, moose were tolerant of close observers when no quick motions or loud noises were made (Denniston 1956).

- in Wyoming, moose moved away when approached on foot within 20-60 feet (Altman 1958).

- in Yellowstone, moose develop considerable tolerance for human disturbance in areas of heavy tourist pressure, but in a control area visitor disturbance caused moose to run and not return to the area until at least the next day (McMillan 1954).

- responses of moose to presence of humans (Corbus 1972).

Mule Deer

- in Colorado, deer were interrupted for longer durations by persons afoot than by snowmobiles; recommended that persons afoot remain more than 334m from mule deer, in winter (Freddy et al. 1986).

SKIING

Bighorn Sheep

- impacts of ski lifts on Desert Bighorns (Graham 1980).

— in California, human disturbance associated with a ski resort; where human use was heavy, Desert Bighorns were forced into poorer habitats (Light 1983).

Elk

— in Yellowstone Park, resulted in average flight distance of 53.5m (Aune 1981) (M.S. Thesis).

— in Yellowstone Park, the median distance at which elk started to move when skiers approached was 400m at Lamar and Stephen's Creek and 15m at Mammoth. Median flight distances moved from disturbance were 42 times greater at Lamar and Stephen's Creek than at Mammoth. No evidence of elk habituation or avoidance was associated with repeated disturbances during the study. At Lamar and Stephen's Creek, elk were displaced from the drainage for at least the duration of human presence and on average returned within 2 days in the absence of human activity. In 5 (of 40) instances, marked elk did not return to the drainages they left when disturbed. Median energy expenditure for movement was 335 Kcal/disturbance (Cassirer et al. 1992) (M.S. Thesis).

— in Elk Island National Park, Alberta, influence of nordic skiers on elk distribution (Ferguson and Keith 1982).

— effects of ski area expansion on elk in mountainous terrain (Morrison 1992) (M.S. Thesis).

Moose

— in Elk Island Park, Alberta, the influence of nordic skiing on moose distribution (Ferguson and Keith 1982).

Mule Deer

— in Yellowstone Park, resulted in average flight distance of 52.4m (Aune 1981) (M.S. Thesis).

Trumpeter Swans

— in Yellowstone Park, "No future activities should be planned which would increase human use of the north shore of Yellowstone Lake and the Yellowstone River from Fishing Bridge to Alum Creek after October 20. Land management agencies should direct human activities away from wintering and nesting sites. . .Winter activities such as snowmobiling or cross-country skiing will cause most swans to fly if the person can be seen. Snowmobile and ski trails should be routed away from river courses" (Shea 1979) (M.S. Thesis).

Wolves and Grizzly Bears

— used GIS to analyze observations of radio-collared wolves and grizzly bears in respect to human activity levels on roads, trails and at ski areas (Purves et al. 1992).

— in Banff, Yoho, and Kootenai Parks, Canada, where winter human use exceeded 10,000 visitors per month, wolves showed aversion to such areas (Purves et al. 1992).

General

— effects of skiing on wildlife in Michigan (Young and Boyce 1971).

ENERGY EXPENDITURES BY WILDLIFE FOR LOCOMOTION

Bighorn Sheep

— prediction of energy expenditures by Rocky Mountain bighorns (Chappel and Hudson 1980).

— energy expenditures resulting from harassment were most damaging when sheep were in poor condition (Geist 1971).

Elk

— in Montana, free-ranging elk herds are generally restricted by snow depths exceeding 46cm (Beall 1974) (Ph.D. Thesis).

— in Montana, activity, heart-rate and associated energy expenditures (Leib 1981) (Ph.D. Thesis).

— energy expenditures for several activities were measured using indirect calorimetry with 5 mule deer and 8 elk; energy expenditures for locomotion in snow increased curvilinearly as a function of snow depth and density. "The additional energy drain on a wintering population on poor range may be an important factor in survival" (Parker et al. 1984:486).

Mule Deer

— see entry for Parker et al. 1984 under "ELK," above.

— in Colorado, when forced from lying to running by persons afoot, increased energy expended from 9 Kcal to 54-127 Kcal; for snowmobiles, this increase was from 2 to 10-25 Kcal (Freddy et al. 1966).

White-tailed Deer

— in New York, snowmobile trails should be kept at least one-half mile from deer concentrations in winter; used energy expenditure calculations to demonstrate danger of snowmobile harassment to winter-stressed deer (Severinghaus and Tullar 1975).

— analysis of deer responses to environmental changes should be on a sequential basis rather than as an overall average; a deer does not respond the same to equally cold weather conditions in November and March. In March, the fat reserve is depleted, females may be carrying fetuses, and requirements for gestation are increasing rapidly (Moen 1976).

— in Maine, deer frequently followed snowmobile trials (Richens and Lavigne 1978).

General

— "While all impacts on animals cannot be documented, it is clear that loss of body reserves has negative effects on the individuals concerned. When combined with other factors such as stressful winters, the animals could die or fail to reproduce. In such cases, populations would decline. When a disturbance occurs over a large region for many years, the population may be unable to continue to reproduce and survive in the area" (Anderson 1995:164).

— running increased the need of ruminants for food (Geist 1971).

— morphological parameters affecting ungulate locomotion in snow (Telfer and Kelsall 1979).

— energetics and mechanics of terrestrial locomotion (Taylor et al. 1981).

STRESS INDUCED BY HUMAN ACTIVITY TO WILDLIFE SPECIES PRESENT IN WINTER IN YELLOWSTONE NATIONAL PARK

Bald Eagles

— human disturbance adversely affected wintering bald eagle distribution and behavior. Distribution patterns were significantly changed, resulting in displacement of eagles to areas of lower human activity, simulated disturbances of persons afoot, in Washington state (Stalmaster and Newman 1978).

— human disturbance is most serious for eagles that depend on large fish or mammal carcasses as their major food source (Anthony et al. 1995).

— human disturbance is an important factor in nest site selection by bald eagles (Murphy 1965).

— modeling cumulative effects of humans on bald eagle habitat (Montopoli and Anderson 1991).

— in Washington state, sensitivity of wintering bald eagles to human disturbance (Russell 1990).

— human disturbance of an avian scavenging guild; includes eagles (Skagen 1980; Skagen et al. 1991).

— human activities had adverse effects on distribution and behavior of wintering bald eagles in Washington state; measured flight distances from simulated human disturbances (Stalmaster and Newman 1978; Stalmaster et al. 1993); high levels of human disturbance during winter could increase energy demands and result in increased mortality rates (Stalmaster and Gessaman 1984).

Bighorn Sheep

— harassment led to increased energy expenditures and was most damaging when animals were in poor condition (Geist 1971).

— at Grand Canyon, studied helicopters and sheep time budgets; frequent alerting affected food intake (Stockwell et al. 1991).

— in Wyoming, all mountain recreationists may stress sheep that they encounter (Thorn et al. 1979).

— harassment has significant impacts on individuals and populations and reduces fitness; passive harassment produces no visible response but may have psychological and physiological effects on sheep (Horejsi 1976).

— in California, human disturbance by recreationists may be limiting sheep populations; measured heart rate responses to harassment (Stemp 1983) (M.S. Thesis).

— cardiac and behavioral responses of bighorn sheep to human disturbance; heart rates varied inversely with distance from road (MacArthur et al. 1982).

— in Rocky Mountain Park, disturbance in critical sheep habitats has been reduced by closure of trails (Stevens 1982).

Black Bears

— assessed the effects of recreational activities on denning ecology of 19 bears for 3 winters in Nevada and California; “data implied that protecting black bear denning areas from human disturbance in winter is important to minimize cub abandonment and needless energetic expenditures by increased winter activity” (Goodrich and Berger 1993).

Canada Geese

— Geese seemed to avoid or leave locations where disturbances restricted feeding (Austin 1988) (Ph.D. Thesis).

Coyotes

— abortion and consumption of fetuses by coyotes following abnormal stress (Gipson 1970).

Elk

— people concentration areas should be one-half mile from elk feeding sites in Wyoming (Ward et al. 1973).

— positive correlation of man-caused disturbance and elevated heart rates in telemetered elk; highest incidence occurred with loud noises and direct interaction (Ward 1977).

— nutrition during gestation in relation to successful reproduction (Thorne et al. 1976).

— in Yellowstone Park, “recurring long periods of limited areas, such as at campsites, appeared to cause limited shifts in elk distribution” (Chester 1976) (M.S. Thesis).

Other Wildlife

— the physiology of alarm in deer mice (Rosenmann and Morrison 1974).

— a 40kg unstressed pronghorn in winter would necessarily consume 900 grams dry matter/day for maintenance and growth. . . 32% higher for animals which were moderately active, and variably increased by cold temperatures (Wesley et al. 1973).

— how close certain passerine birds will tolerate approaching humans (Cooke 1980).

— human disturbance of an avian scavenging guild (Skagen 1988; Skagen et al. 1991).

General

— ecosystem behavior under stress (Rapport et al. 1985).

— "In contrast to sizeable literature of direct effects on wildlife, very few studies have documented impacts resulting from habitat changes induced by recreational activities; . . .the indirect effects of recreation on animal populations are likely to be substantial, but there is little rigorous documentation of these impacts. For invertebrates, amphibians, reptiles, small birds, small mammals, and many fish, these indirect effects are likely to be more substantial than direct impacts of recreationists" (Cole and Landres 1995:192-93).

— snow-based recreation may result in facility construction, fragmenting and reducing the availability of critical habitat; of the snow-based recreational activities, "the impacts of snowmobiling appear to be most pronounced" (Cole and Landres 1995:186).

— "When people intrude into wildlife habitat, stress on populations is one result. Snowmobile activity is a particular problem as people move into wintering areas where animals may already be stressed;. . . animals can be stressed to the point that they require more energy than they can take in, so they must rely on body reserves. Continuous stress from human recreation could eventually cause illness or death of an animal (p. 163); . . ."continuous harassment of animals causes them to expend energy beyond what they can take in during the winter, so some animals can die or fail to reproduce. Stress has been shown to be an important contributor of declining populations in some animals but such population related work is rare" (Anderson 1995:166).

— "From a legal point of view, harassment includes behaviors that indicate an animal has heard a sound, as well as behaviors that indicate aversion;. . .any human-made sound that alters the behavior of animals or interferes with their normal functioning: from a legal point of view constitutes a taking (*e.g.*, Endangered Species Act of 1973; Marine Mammal Protection Act of 1972. (p. 109, Bowles 1993).

— "In polar regions, many animals must rely on stored body reserves and on maintaining low levels of activity to survive winter. Increased human activity in these areas due to increased tourism or industry, for example, will certainly affect their behavior and physiology" (Gabrielson and Smith 1995:104-05).

— at the wildlife community level, "Our understanding of how recreational activities influence communities is just developing. . .;recreationists can directly alter competitive, facilitative, and predator-prey relations, three types of interaction that have the potential to affect community structure and dynamics. Species richness, abundance, and composition in communities can be altered by displacement and through the indirect effects of recreationists on habitat structure. . . Species that are sensitive to the presence of people may be displaced permanently; accordingly, Hammitt and Cole (1987:87) ranked displacement of wildlife as being more detrimental to wildlife than harassment or recreation-induced habitat changes (p. 173). Depending on the species that are lost or the interspecific interactions that are uncoupled by displacement, the presence or abundance of other species may also be affected (Gutzwiller 1995:177).

— nonconsumptive users of wildlife do not exist; gives examples of adverse impacts on wildlife from recreationists and scientists (Weedin 1981).

— the concept that some outdoor recreational activities are nonconsumptive is rejected; includes human impacts on wildlife (Wilkes 1977).

— in national parks, managers must realize that these areas have a finite capacity for absorbing human disturbances such as sightseeing, that may alter energy pathways, disturbing vegetation and wildlife (Houston 1971).

— the physiology of fear and anxiety in man and other animals; physiological and behavioral responses to disturbance; a reference book (Mayes 1979).

— "The adaptive characteristics of wildlife, the recreationists behavior, and the context of the disturbance all seem to be important" (Roggenbuck 1992).

— ecosystem behavior under stress (Rapport et al. 1985).

— trends expected in stressed ecosystems (Odum 1985).

— discussed environmental effects of off-road vehicles, particularly snowmobiles. "Clearly the effective way to protect fish and wildlife is not by restricting hunting or harassment alone, but by banning these vehicles from important habitats" (p. 25); harassment caused an unusual number of abortions in wild animals (Baldwin 1970).

— in Yellowstone Park, elk, bison, coyote, mule deer, and moose in that order, were the most frequently encountered wildlife. Wildlife developed crepuscular activity patterns, some displacement from areas adjacent to trails occurred, movement across trails was inhibited by traffic and by the berm created by plowing and grooming operations. Harassment of wildlife by snowmobilers and skiers increased energy expenditure by wildlife. Effects of winter recreationists on the physical environment included minor air and snow pollution by snowmobile exhaust, litter, noise pollution, and limited physical damage to soils and plants. Study area was portions of Madison, Firehole, and Gibbon River valleys (Aune 1981) (M.S. Thesis).

ROADS

Bald Eagles

— in Washington state, wintering eagles initially used areas isolated from a road and receiving little human use, and only when food became less available in these areas eagles utilized areas having more human activity (Serveen 1975) (M.S. Thesis).

Bears

- in Mt. McKinley Park, some bears were attracted to the park road (Tracy 1977) (M.S. Thesis).

- in Yellowstone Park, bears appear to avoid carrion near occupied roads; there has been some springtime avoidance by emerging bears of the area (and available carrion) within 3 miles of the Old Faithful developed area and within 0.25 miles of active roads in the Firehole and Gibbon valleys. (Bear species not specified). (USDI National Park Service 1990:64).

- in Banff, Yoho and Kootenai Parks, the GIS system was used to analyze locations of radio-collared grizzly bears with respect to roads, trails, and ski areas. Carnivore migration corridors must be preserved or widespread habitat alienation can occur (Purves et al. 1992).

- in Yellowstone, in 1995, 6 black bears were known to have been hit by vehicles, one of which is known to have died; no grizzlies were known to have been hit by vehicles (Anon. 1996).

Bighorn Sheep

- in Alberta, heart rates of bighorns varied inversely with distance from road (MacArthur et al. 1979).

- in Rocky Mountain Park, trail closures have reduced visitor use of critical sheep habitats, reducing disturbance of sheep (Stevens 1982).

- in Alaska, bighorn sheep that occupy ranges away from the Denali Park Road must cross the road during seasonal migrations, but have not habituated to traffic even though the road has been there for 54 years (Dalle-Molle and Van Horn 1991).

Bison

- in Yellowstone and Grand Teton Parks "Bison. . .travel on groomed and plowed roads" (USDI, National Park Service 1990:62).

Deer

- on winter ranges in Colorado, deer avoided areas near roads, particularly within 200 meters of roads (Rost 1975) (M.S. Thesis).

— in Washington state, deer showed a general reduction of use up to 1/8 mile from roads, depending on amount of roadside cover; deer were substantially affected in meadows where roadside cover was lacking (Perry and Overly 1976).

— quantified impacts on deer of management activities including roads (Thomas 1979).

Elk

— on winter ranges in Colorado, elk avoided areas near roads, particularly within 200 meters of roads (Rost 1975) (M.S. Thesis).

— construction of roads in elk habitat effectively eliminated prime area from elk production (Pederson 1979).

— in Idaho, road closures allowed elk to remain longer in preferred areas (Irwin and Peek 1979).

— in Glacier Park, habituation to roads made elk more vulnerable to poaching (Singer 1975).

— in Yellowstone Park ". . .elk . . .travel on groomed and plowed roads" (USDI, National Park Service 1990:62).

— human activity on forest roads alters distributions of Roosevelt elk activity; monitored 6 cows for one year (Witmer and deCalesta 1985).

Foxes

— in Mt. McKinley Park, some foxes were attracted to the park road (Tracy 1977) (M.S. Thesis).

Moose

— in Yellowstone and Grand Teton Parks, "moose travel on groomed and plowed roads" (USDI, National Park Service 1990:62).

Mountain Lions

— in Arizona and Utah, lions selected home areas with lower road densities (Van Dyke et al. 1986).

Wolves

— on Isle Royal, wolves avoid contact with humans; management suggestions include limiting visitation, no further trail development and discouragement of winter visitor use (Peterson 1977).

— in Banff, Yoho, and Kootenai Parks, the GIS system was used to analyze locations of radio-collared wolves with respect to roads, trails, and ski areas. Wolves showed aversion to areas where human use exceeded 10,000 visitors per month (Purves et al. 1992).

— in Jasper Park, wolves tend to avoid traveled roads (Carbyn 1974).

— describes interrelationships of wolves, prey, and man in Alaska (Gasoway et al. 1983).

— in Kenai NWR, Alaska, radio-collared wolves avoided roads open to the public but used other roads with limited human use; management plans for wolves may include reduction of roads and seasonal or permanent gating of roads to reduce human access (Thurber et al. 1994).

General

— in Mt. McKinley Park, among ungulates, "females with young were the most easily disturbed by human activity on the park road" (Tracy 1977) (M.S. Thesis).

— when trails are developed, "discarded human food wastes provide different sources of food for animals, affecting their population structure"(Anderson 1995 citing Knight and Cole 1991).

THERMAL AREAS

Bald Eagles

— in Grand Teton and Yellowstone Parks, "a relationship seems to exist between open water and nest site selection. . .Thus 87% of the nesting territories were located either in major rivers, or lakes within 5 km of their inlets or outlets, or <u>along streams or lakes in thermal areas</u>" (Alt 1980:40) (M.S. Thesis). (emphasis added).

— in the Greater Yellowstone Ecosystem, the primary wintering areas are along major rivers, usually near concentrations of wintering ungulates and open water where waterfowl and fish are available. Thus, food availability appears to determine bald eagle use of an area during winter (p. 38). <u>Thermal areas</u> keep some waters open in Hayden and Pelican Valleys and small portions of Lewis and Heart Lakes, which give bald eagles access to wintering waterfowl and fish (Swensen et al. 1986) (emphasis added).

— in Yellowstone, in winter, “Eagle activity is greater along streams that remain ice-free and in thermal-influenced areas. . .” (USDI National Park Service 1990:12) (emphasis added).

— in Yellowstone, there are 19 active territories and eagles “can be seen year round in the park, nesting usually in riparian zones along the Madison and Yellowstone rivers where raptors can find fish at any time of year in thermally influenced open waters (p. 5) . . .eagles also scavenge on the carcasses of winterkilled elk and bison, particularly on the northern range and in the Firehole Valley” (Anon. 1995:6) (emphasis added).

Bison

— in Yellowstone Park, “The survival factor, for bison in parts of Yellowstone, may be the existence of thermal areas. As previously discusses, thermally active areas do not attract large numbers of bison for the winter, but the use of certain areas for brief periods, particularly at times of prolonged cold combined with heavy snow depth, as observed by Jim Stradley, or in late winter as seen during the study period may determine the lower limit to which the population numbers drop. . .where winters are more severe, those valleys which have bison have either extensive thermal or warm areas, or else many small ones among which movement is possible. Some streams which remain unfrozen because of an influx of warm water are an additional feature of most wintering areas. . .” (Meagher 1970) (Ph.D. Dissertation) (emphasis added).

— “Total use by bison of all areas where thermal influences alleviated otherwise more severe winter conditions was more than the use of thermally active sites. In the three valleys of Hayden, Pelican and the Firehole the amount of bison use made of sedge bottoms with lessened snow depths, and the ice-free streams indicated that thermal influence was important in maintaining wintering populations (p. 100) (Meagher 1970) (Ph.D. Dissertation) (emphasis added).

Elk

— in Yellowstone, elk habitat along the Madison, Firehole and Gibbon rivers has deeper snow than the northern range; consequently thermal areas with snow-free vegetation or shallow snow are very important to winter habitat for elk (USDI National Park Service 1990:10).

Trumpeter Swans

— in Yellowstone Park, “Snowmobile and ski trails should be routed away from river courses” (Shea 1979) (M.S. Thesis).

— in Yellowstone, "Trumpeter swans remain in the area year-around and are joined by winter migrants. About nine pairs nest in Yellowstone, and in winter the population increases to somewhere between 40 and 300, depending on the number of migrants spending at least part of the year there. . .The slow flowing open water habitat required for swan survival is increased by thermal activity, but even in Yellowstone it becomes scarce during the coldest part of the winter: (USDI National Park Service 1990:16). (emphasis added).

General

— in discussing indirect effects of recreation on wildlife, "The vulnerability and variety of the habitat, and its importance to wildlife, should also be considered" (Cole and Landres 1995:183). (emphasis added).

— "In the long term, if extensive habitat alteration occurs for animals that have a limited distribution, the population of a particular species may experience substantial declines" (Anderson 1995:157).

ENERGETICS AND NUTRITION OF WILDLIFE IN WINTER

Bears

— in Yellowstone, available food for grizzly bears . . .is the greatest threat to survival of the bear population; increasing recreational activities in the Yellowstone area will increase this problem (Knight et al. 1988).

— grizzlies commonly scavenged in dead elk; total elk mortality in study area of Firehole, Madison and Gibbon River drainages in winter-spring 1969-70, was 268 elk; in Yellowstone Park's Firehole, Madison and Gibbon River drainages, grizzly bears culled elk with low energy reserves (Cole 1972).

Bighorn Sheep

— prediction of energy expenditures by bighorn sheep (Chappel and Hudson 1980).

Bison

— in Yellowstone Park, bison "Use of the plowed road for relatively easy and energy-efficient travel probably facilitated learning and a rapid increase in numbers" (Meagher 1989:674). Author here was referring to the plowed road between Tower and Mammoth, where daily road plowing began in the late 1940s.

— in Yellowstone Park, in Hayden, Pelican and Firehole Valleys “. . .thermal influence was important in maintaining wintering populations” of bison (p. 100), sites of thermal influence “were of great importance to the bison population during brief but critical periods” (p. 100). “In spite of limited use, these areas probably represent the margin of survival of the herd groups in Firehole, Hayden, and Pelican Valleys during the most extreme winter conditions” (p. 101). “The survival factor, for bison in parts of Yellowstone, may be the existence of thermal areas” (p. 111), and “. . .thermally active areas do not attract large numbers of bison for the winter, but the use of certain areas for brief periods, particularly at times of prolonged cold combined with heavy snow depth. . . or in late winter. . . may determine the lower limit to which population numbers drop” (p. 112) (Meagher 1970) (Ph.D. Dissertation).

— in Yellowstone Park, winter weather is a population regulating influence on bison (Meagher 1976).

— in Yellowstone Park’s Madison-Firehole range, in winter, progressive nutritional restriction in bison was greater than on the northern range or in Pelican Valley (DelGuidice et al. 1994).

Elk

— in Yellowstone Park, assessed nutritional deprivation of cow elk groups on northern range and Madison-Firehole range and estimated elk density and calf:cow ratios. Found significant declines in calf:cow ratios from early to late winter were associated with nutritional deprivation, particularly in areas of high elk density and/or deep snow (DelGuidice et al. 1991).

— passive harassment of elk resulting from human activities caused overgrazing of marginal habitats, which may be especially harmful to elk during severe winters when their energy budgets are stressed (Morganti and Hudson 1980).

— telemetered heart rates of elk affected by human disturbance (Ward and Copal 1980).

— effects of nutrition during gestation in relation to successful parturition in elk (Thorne et al. 1976).

Moose

— seasonal energy expenditures and thermoregulatory responses of moose (Renecker and Hudson 1986).

— the metabolic rate of moose during winter (November to March) was similar to values reported for other wild ungulates; tame moose; Alaska (Regelin et al. 1985).

Mule Deer

— urine cortisol measurement in winter provide a tool for assessing population condition in mule deer (Saltz and White 1991).

White-tailed Deer

— lowest ecological metabolism in white-tailed deer occurs in winter; an adaptation for energy conservation. Resource needs lower when range resources are reduced. The timing of spring arrival is important to population dynamics, with effect pronounced 2 years later when fawns become breeders (Moen 1978).

General

— "During winter, processes influencing energy intake, rather than energy expenditure, have a much greater impact on energy balance of ungulates (Hobbs 1989), suggesting that disruption of wildlife while feeding is of greater concern than causing wildlife to flee. Mammals show a weaker response to humans during the winter months than at other times of the year. Hamr (1988) reported that chamois were least sensitive to recreationists when snow was deep, forage was inaccessible, and energy conservation was decisive to survival" (Knight and Cole 19959:73-74).

— discusses maintenance metabolism in herbivores (book) (Hudson and Christoperson 1986).

— the energetic cost of cratering (digging) through uncrusted snow (by caribou) was 118 Joules/stroke, whereas that cost was 481 Joules/stroke when cratering through snow compacted by a snowmobile (Fancy and White 1985).

NOISE

Birds

— seem to habituate more rapidly to mechanical noise than to human presence (Gabrielsen and Smith 1995:104).

Deer

— seem to be considerably more tolerant of noise than deer are (Bury 1978).

Elk

— seem to be considerably less tolerant of noise than deer are (Bury 1978).

Fish

— detection and reaction of fish to infrasound (Enger et al. 1993).

Mice

— effects on blood eosinophil levels and adrenals of mice (Anthony and Ackerman 1995).

General

— effects of snowmobile noise on large game animals appear to vary by species (Bury 1978).

— data for domestic and laboratory animals were extrapolated for wildlife; potential effects included masking of signals and calls; chronic exposure could result in physiological and behavioral changes; effects would most likely be cumulative (Dufour 1971).

— hearing in vertebrates, a psychophysics data book (Fay 1988).

— effects of noise on wildlife; quantifying the acoustic dose when determining the effects of noise on wildlife; a perspective of government and public policy regarding noise and animals (a book) (Fletcher and Busnel 1978).

— mammals habituate more rapidly to mechanical noise than to human presence (Gabrielsen and Smith 1995:104).

— noise effects on wildlife (Tennessee State Univ. 1971).

— presents an animal response model to quantify effects of noise on wildlife (Janssen 1978).

— a method for measuring wildlife noise exposure in the field (Kugler and Barber 1993).

— effects of noise on wildlife and other animals; sources potentially disturbing to wildlife include recreational vehicles (U.S. Environ. Protection Agency 1971).

— effects on wildlife (Bollinger et al. 1973).

— reviews recreational noise influences on wildlife, including snowmobiles; ". . .noisy vehicles will affect them at much greater ranges than humans. However, if they are habituated to vehicle noise at levels that are not aversive, humans laughing and yelling can arouse responses at greater ranges than snowmobiles (p. 113). With repeated exposure, all vertebrates habituate or adapt behaviorally and physiologically. . .One form of adaptation is sensitization (an increase in responsiveness) resulting from negative experiences associated with noise; vertebrates from fish to mammals can learn to avoid noise associated with danger. . .Motivations such as hunger that keep animals from paying attention to noise lessen its aversiveness. . .Guidelines that protect human hearing apply to many terrestrial mammals because they are based on studies of laboratory animals (p. 115). Noise can doubtless affect communication and sleep in animals. Noise is suspected of causing stress-related illness in both humans and animals. . .Wild animals can abandon favored habitat in response to disturbances or incur energetic expenses after reacting. . .Masking and hearing loss represent a life-threatening hazard in predator-prey interactions. . .noise might cause animals to become irritable, affecting feed intake, social interactions, or parenting. All these effects might eventually result in population declines. Even if populations were unaffected, genetically determined differences in susceptibility might exert subtle selection that eventually could affect fitness." Each of these potential effects is considered in detail (p. 116) (Bowles 1995).

WILDLIFE HABITAT CORRIDORS

— importance of migration between fragments of nature reserves (Burkey 1989).

— habitat patch connectivity and population survival (Fahrig and Merriam 1985).

— the need for movement corridors (Harris and Gallagher 1989).

— dispersal and connectivity in metapopulations (Hansson 1991).

— ecological considerations in the design of wildlife corridors (Lindenmayer and Nix 1993).

— consequences and costs of wildlife corridors (Simberloff and Cox 1987).

— effects of habitat fragmentation on extinction (Wilcox and Murphy 1985).

— for cougars (Beir 1993).

— in Colorado, <u>mule deer</u> migration was strongly correlated to winter severity; demonstrated strong fidelity to winter ranges; fidelity to individual movement patterns is long range, possibly for life (Garrott et al. 1987).

— carnivore habitat corridors must be preserved or widespread habitat alienation can occur for <u>wolves</u> and <u>grizzlies</u> in Yoho, Kootenai and Banff National Parks (Purves et al. 1993).

POLLUTED SNOW

— polluted snow in southern Norway, in winter (Elgmark and Langeland 1973).

— polluted snow effects on freshwater and aquatic organisms (Hagen and Langeland 1973).

— lead emissions from snowmobiles as a factor in lead contamination of snow (Ferrin and Coltharp 1974).

— snowmobile engine emissions and their impact (Hare and Springer 1974).

— in Minnesota, a study of small mammals indicated that snowmobile use may trap toxic air in snow (Jarvinen and Schmidt 1971). (Also see "Snomobiling - Subnivian Mammals/ Small Mammals" section of this report).

— "Pollutants produced by recreational activities (*e.g.*, gasoline and oil leaked by off-road vehicles) or sewage effluent may take considerable time to flow into groundwater or be flushed from the soil surface to streams or lakes" (Cole and Landres 1995:191).

— contamination of vegetation by tetraethyl lead (Cannon and Bowles 1988).

APPENDIX II. POTENTIAL OPPORTUNITY AREAS

Potential Opportunity Areas (POA) are lands in the Greater Yellowstone Area that possess the physical and social conditions desired by various winter recreationists. POAs describe an area's recreation potential, not necessarily its existing condition. The experiences range from those that are easily accessible and highly developed (such as snowmobiling to Old Faithful) to those that are considered remote backcountry experiences (such as skiing in the Absaroka-Beartooth Wilderness). These areas are mapped in *Winter Visitor Use Management: A Multi-agency Assessment, Final Report of Information for Coordinating Winter Recreational Use in the Greater Yellowstone Area*, Greater Yellowstone Coordinating Committee, 1999.

Each of the descriptions below includes some of the most important attributes that the opportunity area should possess, setting it apart from the others. Though the names of the opportunity areas are primarily reflective of snowmobile and ski activities, other recreation uses such as ice climbing, trapping, hunting, ice fishing, photography, dog sledding, using snowplanes, and four-wheel driving could be appropriate in various opportunity areas. The activities that could be accommodated in each area depends on the mutual compatibility of the activities and the social and environmental conditions necessary to support quality recreational experiences, while protecting wildlife and other resources. For example, in many "groomed motorized routes" (Opportunity Area 4), cross-country skiing and other nonmotorized activities could occur. In "groomed nonmotorized routes" (Opportunity Area 7), many different activities could occur, but motorized activities would not be compatible.

Comparative use levels are described for each opportunity area. For example, the use level considered consistent with "groomed motorized routes" (Opportunity Area 4) is described as "high" while the use level for "motorized routes" (Opportunity Area 5) is described as "moderate." More detailed analysis, beyond the scope of this assessment, will be required to quantify the actual numbers that constitute "high" or "moderate" use. Existing use levels vary widely in different areas that might be allocated to the same opportunity area classification. The team emphasizes that the described use levels represent the *upper limits* that resource managers believe are compatible with quality recreational experiences. It is neither expected nor desired that all areas reach the upper use limits.

1. DESTINATION AREAS

These are highly developed, highly used hubs of concentrated recreational use on public lands or lands under permit by public agencies. Located on travel routes, these areas provide support services for a wide variety of activities and may include lodging, food services, instruction, and interpretation. Destination areas may be staging and access points for recreational activities serving a fairly large surrounding area. Multiple uses are expected to occur, and some use conflicts are tolerated as are some resource impacts. (This analysis does not include towns, cities, and communities; they appear on the base map for reference purposes only.)

2. PRIMARY TRANSPORTATION ROUTES

These are highways open year-round and used for commercial as well as recreational traffic. Primary transportation routes have a recreational component, such as accessing trailheads and winter use destination areas, but are primarily travel corridors.

3. SCENIC DRIVING ROUTES

Forest and park visitors use these roads primarily to enjoy the surrounding area scenery, to access trailheads, and to access winter use destination areas. The roads are open all year to wheeled vehicles, but generally carry less traffic than the primary transportation routes. Because viewing scenery and wildlife, and enjoying the drive are the primary experience for many users, visual quality and clean air are important. Some sound associated with highway travel is tolerated.

4. GROOMED MOTORIZED ROUTES

Along these routes, motorized and nonmotorized activities occur in safe, highly maintained corridors and traverse a variety of settings. Destinations and attractions along the way are of high interest. Appropriate developments could include restrooms, warming huts, food services, interpretive facilities, gas stations, and other conveniences. Terrain on the groomed surface is gentle and suitable for novices. Smooth, groomed snow surfaces are important. High use levels are expected, and relatively more sound is tolerated than in the other opportunity areas.

5. MOTORIZED ROUTES

Generally routes are well-marked and relatively safe corridors for motorized and nonmotorized activities. Included in this opportunity class are moderate- to high-density snow play areas. Facilities are usually limited to those located at trailheads. Some of these routes may be distant from access points and roads, but these are not places where one is likely to get lost. Greater skill levels are required here than on groomed routes because snow surfaces are not expected to be as smooth. Varied terrain is desirable for moderately challenging experiences. Moderate use levels are expected, and while some snow machine sound is tolerated, it is generally expected to be more intermittent than the relatively constant sound along the groomed routes. These routes may be groomed but not to the standards of POA 4.

6. BACKCOUNTRY MOTORIZED AREAS

These combine marked but ungroomed motorized routes and low- to moderate-density snowmachine play areas. Challenge and adventure are important. Little in the way of support facilities, other than parking at access areas, is needed. Use levels are low to moderate. Moderate to high levels of remoteness are desirable, as are scenic views, challenging terrain, deep snow, and untracked powder. Intermittent noise is tolerated. Users need experience and skill for a safe outing.

7. GROOMED NONMOTORIZED ROUTES

People come for nonmotorized experiences in safe and often well-maintained corridors. These areas are used as much for exercise and race training as for recreation, but they are suitable for beginners where the terrain is gentle. Nearby support services are desirable and may include restrooms, trailheads, informational and directional signing, instruction, lodging, and warming areas. Fairly high use levels are expected. Sound and visual evidence of other nearby activities and from adjacent opportunity areas are tolerated but not desirable.

8. NONMOTORIZED ROUTES

Park and forest visitors use ungroomed nonmotorized routes to ski or snowshoe in a natural setting on routes that are apparent but not necessarily marked. Developments in these areas are limited to access points and parking. Gentle topography provides interest but not a high level of challenge. Consistent snow is important, but various snow conditions are tolerated. Low to moderate use levels are expected, but a high level of sound is disruptive to the experience. Outings are generally one day or shorter in duration, although rental cabins may be the destination along some routes.

9. BACKCOUNTRY NONMOTORIZED AREAS

These provide backcountry experiences characterized by remoteness and freedom from development and other human traces. Solitude, low use levels, and absence of noise are important elements of this experience. Terrain is varied and provides moderate to high levels of challenge and adventure. Backcountry and route-finding skills are required for a safe outing. Outings may be more than one day in duration.

10. DOWNHILL SLIDING (NONMOTORIZED)

Users of these areas are looking for challenge, adventure, and opportunities to improve skiing and snowboarding skills. While absence of crowds, developments, and regulation are important to this experience, moderate use levels are tolerated. Untracked snow provides the ultimate satisfaction for these users. Quiet is desirable, but some sound from nearby activities may be tolerated. The best areas are close to access points.

11. AREAS OF NO WINTER RECREATIONAL USE

These are areas where administrative closures protect wildlife winter range and other lands not managed for recreation, or where use is prohibited because of sensitive resources, such as thermal features.

12. LOW-SNOW RECREATION AREAS

Low-snow and snow-free conditions during much of the winter characterize these areas. Hiking, fishing, hunting, bird watching, mountain biking, or ATV riding and 4-wheel drive activities if consistent with travel management plans are common activities that could occur. If snow is present motorized activities occur in designated routes consistent with travel management plans. Snow related winter uses are appropriate unless otherwise regulated.

WINTER RECREATION IMPACTS TO WETLANDS: A TECHNICAL REVIEW

Prepared for Arapaho-Roosevelt National Forests, White River National Forest, and Black Hills National Forest

Submitted to Steve J. Popovich
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ABSTRACT

In this report, we present a review of the scientific literature as it pertains to the impacts of winter recreation activities on the mountainous ecosystems of the central and southern Rocky Mountains, with an emphasis on the impacts to wetlands, including fens. Winter recreation activities can affect vegetation, soils, and hydrologic regimes, with impacts varying in relation to the intensity, frequency, and extent of disturbance. Impacts are primarily manifested through changes in snowpack conditions such as density, snow water equivalent, and transmissivity to air and water, and through the effects of compaction on thermal profiles. Gradients of intensity of impact exist between activities associated with alpine skiing, such as mechanized grooming, and those associated with nonmotorized recreation like snowshoeing. Winter recreation can have significant impacts to ecosystems and should be incorporated into management and planning of wetland resources.

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Introduction

Wetlands are important resources in the Rocky Mountain region and provide a wide range of ecological functions. Although wetlands occupy a small proportion of the total land area, they are important centers of local and regional biodiversity, providing habitat for many rare taxa (Bedford and Godwin 2003, Wolf et al. 2006, Gage and Cooper 2006). Over 16% of dicot species and 45% of monocot species on the United States Forest Service (USFS) Region 2 sensitive species list occur in wetlands (USFS 2007). Many biogeochemical, physical, and ecological processes occur primarily in wetlands, contributing valuable goods and services such as recreation, groundwater recharge, nutrient removal, and the maintenance of biodiversity (Baron et al. 2002, Boyer and Polasky 2004).

Because of the widespread loss and degradation of wetlands throughout North America (Tiner 1984, Office of Technology Assessment 1984, Patten 1998, Brinson and Malvarez 2002), laws and regulations directed at wetland conservation have been developed. Wetlands are managed by agencies including the US Army Corps of Engineers and the Environmental Protection Agency under section 404 of the Clean Water Act, which regulates the discharge of dredged or fill material into waters of the United States, including wetlands. Wetlands are also the focus of many state and local government regulations (Environmental Laboratory 1987, Tiner 1999).

Within the USDA Forest Service, federal and agency-specific regulations and directives influence the management of wetlands. Executive Orders 11988 (floodplain management) and 11990 (protection of wetlands) of 1977 direct federal agencies to avoid adverse impacts to floodplains if practicable alternatives are available. Guidance on fens is provided by the USFS on a regional basis: USFS Memo 2070/2520-7/2620, *Wetland Protection – Fens,* signed by the Region 2 Director of Renewable Resources on March 19, 2002, emphasizes the protection, preservation, and enhancement of fens. Individual forests may also include specific language pertaining to wetland resources in their Land and Resource Management Plans or other forest planning documents. The Medicine Bow and Routt National Forests' Land and Resource Management Plan describes managing for “the ecological values of unusual plant communities (like alpine tundra), special features (like talus, coves, cliffs, and wetlands) and sites of high biological diversity” (USFS 2001).

A key element of effective wetland management is to understand the anthropogenic impacts that affect wetland structure and function. Wetlands may be deleteriously affected by a wide range of activities, with impacts being either direct, such as the draining of a wetland, or indirect, for example the alteration of hydrologic and sediment regimes due to changes in land use in contributing watersheds (Brinson 1988, Bedford 1999, MacDonald 2000). One general class of potential impacts that are poorly understood originates from winter recreation activities. Driven by demographic and economic shifts, the Rocky Mountain region has seen large increases in winter recreation, forcing land management agencies such as the USFS to address issues of winter recreation in planning and management.

A variety of studies have examined summer recreation impacts on ecosystems. For example, there is an extensive literature addressing the effects of hiking and camping on soils and vegetation (Cole 1995, Marion and Cole 1996, Leung and Marion 1999, Thurston and Reader 2001, Sutherland et al. 2001, Marion and Farrell 2002, Cole and Monz 2003, Cole and Monz 2004). In addition, there is a body of literature detailing disturbance impacts from transportation in far-northern and high-elevation sites (Gersper and Challinor 1975, Challinor and Gersper 1975, Chapin and Shaver 1981, Felix et al. 1992, Kevan et al. 1995, Emers et al. 1995, Harper and Kershaw 1996). However, relatively few studies have examined the potential impacts from winter recreational uses on wetlands in the region. In snow-covered landscapes, activities that affect the distribution and physical characteristics of the snowpack have the potential to affect ecological systems and processes.

Our goal in this report is to provide a review of the available scientific literature on the impacts of winter recreation on the physical characteristics of snow and soils and the resulting ecological impacts to vegetation, fauna, and ecosystem function. Our emphasis is on fens, but we draw upon relevant ecological literature from other wetland and even non-wetland ecosystem types. Geographically, we focus on the mountain environments of the central and southern Rocky Mountains, but address relevant literature from around the world.

Approach

For this report, we conducted a literature review using electronic bibliographic databases available through the Colorado State University library system. Keyword searches on a broad array of topics related to winter recreation, wetlands, snow properties and processes, and winter ecology were done in Web of Science, Science Direct, and Google Scholar. Dissertations and theses were searched using Proquest's Digital Dissertation Database and broad searches for relevant information were made using Google. Citations were managed using Procite v 5. References in the Literature cited sections of particularly relevant papers and reports were identified and added to the Procite database. Over 200 references were added to the database and reviewed as part of the literature search.

Overview of winter recreation activities and their impacts

The nature and severity of impacts vary depending on the activity, as well as the frequency and timing of use. For example, motorized activities, such as grooming for Nordic or alpine skiing and snowmobile use, alter air and snow chemistry through exhaust emissions and fluid leakage (Sive et al. 2003, McCarthy 2007), which are impacts not associated with non-motorized activities such as snowshoeing or cross-country skiing. A single pass of a snow machine has less of an impact on snow properties than multiple passes.

Some effects are common to all activities, most notably snow compaction. However, the amount and extent of impact differs widely. A single narrow ski track is far less likely to significantly affect hydrologic or ecological processes in wetlands then a series of intensely-used snowmobile trails. Although we make generalizations on the relative impacts of different activities, impacts to any specific area will vary in relation to site-specific visitor use and snowpack conditions.

Among winter recreation activities, developed alpine skiing entails the most intense impacts, given the extensive landscape modifications involved in developing and maintaining the infrastructure for ski resorts. Impacts include those associated with the creation of ski runs (tree removal, machine and grading of slopes, etc.), infrastructure and maintenance (access roads, chairlifts, etc.), and operations (grooming, skier use, artificial snow making, etc.). Activities such as the grooming of ski slopes and trails are generally not undertaken until a minimum snow depth occurs; however, this depth is often determined more by safety considerations for the machinery than for ecological reasons (Sanecki et al. 2006a). Artificial snow making increases water and ion concentrations to slopes, which may alter nutrients available for plants. Snow additives, including potentially phytopathogenic bacteria, are often used to enhance ice crystal formation (Rixen et al. 2003), with unknown effects on wetlands. Individually and cumulatively, impacts from alpine skiing operations can be dramatic to plants and soils, including alterations of plant composition and cover and soil physical and chemical properties (Fahey and Wardle 1998, Pickering et al. 2003, Keller et al. 2004, Wipf et al. 2005).

Snowmobiling is common in many National Forests in the region. Impacts to snow characteristics and plant communities have been studied outside the region (Neumann and Merriam 1972, Foresman et al. 1976, Keddy et al. 1979), but data from the southern and central Rocky Mountains ecosystems is lacking. General impacts include those to snow properties, such as changes to thermal regimes from compaction, as well as noise and chemical emissions from exhaust (Ryerson et al. 1977, Olliff et al. 1999, Sive et al. 2003, McCarthy 2007). Because of their significant weight, snowmobile impacts to snow properties occur with low frequency use, even a single pass of a machine (Keddy et al. 1979).

The two primary nonmotorized winter recreation activities are Nordic (cross-country) skiing and snowshoeing. The primary impacts from these activities involve snow compaction. Because of the lower mass of a skier compared to snow machines, impacts are more moderate and dependent on a high frequency of use for significant impact to vegetation and soils to occur.

Visitor use data is collected by the USFS as part of the National Visitor Use Monitoring (NVUM) project and reported in terms of standardized “National Forest visits” in order to provide comparable estimates of visitor use. Winter recreation activities that are assessed include snowmobiling, cross-country skiing, and snowshoeing. In National Forests of Colorado, there are approximately 2,133 miles of groomed winter trails open to snowmobiles, with an available land area of approximately 9,355,419 acres (Bluewater Network 2002). Over 2 million cross-country ski and snowshoe visits and 1.3 million snowmobile visits occur annually in Colorado (Bluewater Network 2002).

Physical properties of snow

Snow is a highly complex material, exhibiting a wide range of physical characteristics depending on its structure. The physical structure of snow is a function of the bonding patterns of water molecules and varies depending on factors such as the air temperature when the snow formed, and the history of freezing and thawing in the snowpack (Halfpenny and Ozanne 1989). Differences in the morphology of snow influences snow's albedo, thermal conductivity, and transmissivity to air and water. In snow-covered landscapes, the direct effects of recreational activities on underlying vegetation and soils is generally limited; rather, the effects are primarily indirect, a function of the altered physical characteristics of the snowpack.

Snow density, defined as the depth of water obtained by melting a unit depth of snow, can vary widely depending on the temperature of the storm, the duration of time since snow fall, and other environmental factors such as wind. Density values in freshly fallen snow vary from ~0.05 if the temperature is -10°C to 0.20 at 0°C, but rapidly increases following deposition due to the effects of the gravitational settling, melting and re-crystallization, and wind packing (Dunne and Leopold 1978). By spring snow densities may range from 0.30 to 0.50. This variability is what makes the estimation of snow water equivalent (SWE) from snow depth measurements unreliable. The effect of human recreational activities on snow density is a primary concern, although the magnitude of impacts varies with intensity and extent. Regular mechanical grooming will have a significantly greater effect than infrequent cross-country skiing.

Winter snow typically undergoes significant morphogenesis during the winter (Colbeck 1982). Melting and recrystallization of snow flakes increases snow grain size, leading to changes in water holding capacity, density, and physical stability. The temporal sequence of storms and the length and meteorological conditions during interludes can create complex stratigraphic variation in snow characteristics. Of particular interest to backcountry skiers and avalanche forecasters, the complex three-dimensional nature of snow packs is highly variable over space and time.

Snow distribution represents the time integration of accumulation and ablation, strongly influencing hydrologic and ecological processes (Deems 2007). Snow layering and compaction influence snow thickness, SWE, temperature profiles, and surface runoff (Xue et al. 2003). In many snow-covered landscapes such as the upper subalpine and alpine tundra, snow redistribution by wind may be a more important factor influencing snow depth than actual precipitation averages. Physiography interacts with wind to create areas with greatly higher or lower snow depths.

The windward sides of exposed ridges in the alpine are generally snow free throughout the winter, exposing sites to the desiccating effects of winds and severely limiting vegetation diversity and cover. In contrast, leeward sides of ridges and depressions can accumulate incredible depths of snow due to drifting effects, remaining snow-covered through most or all of the growing season. These factors are key drivers of ecological form and function in subalpine and alpine environments (Billings and Bliss 1959, Walker et al. 1993, Heegaard 2002).

Snow melting rates are also influenced by factors such as the density and height of woody plants. Snow strongly reflects shortwave radiation, but readily absorbs the long-wave energy given off by objects like trees or structures. Snow in open wetlands receive less long-wave radiation and may persist longer than the same depth of snow in more shaded forests.

Effects on snow properties

Snow compaction results in large increases in snow hardness. Standardized resistance values showed a threefold increase in season-long snow hardness in groomed sites compared to non-groomed sites subject to skiing in the Austrian Alps (Meyer 1993). Working in New Zealand, Fahey et al. (1999) also documented significant increases in snow penetration resistance, but with the effect limited to early in the season.

The effect of different recreation activities upon the amount of snow compaction varies as a function of the force exerted by the passing person or vehicle and the frequency of passes. Snowmobiles weigh significantly more than an individual skier, for example; however, the force exerted per unit area may be comparable, given the narrower track of the skier (Halfpenny and Ozanne 1989). In general, more compaction occurs with an increased number of passes, although the greatest impact is usually from the first pass (Figure 1)(Keddy et al. 1979). Data presented by Keddy et al. (1979) suggest that several passes throughout the winter following snowstorms may cause more overall snow compaction than an equivalent number of passes on a single occasion. The amount of compaction typically is attenuated with increasing depth below the snowpack surface (Halfpenny and Ozanne 1989).

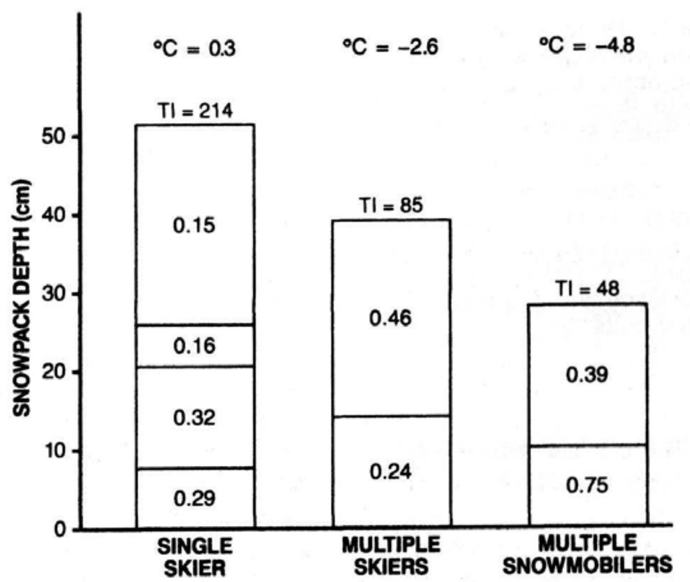

Figure 1. Impacts to snow pack depth, density, and thermal characteristics from winter recreation activities. Reductions in the thermal index (TI) and ground/snowpack interface temperature (along top of figure) and an increase in density (values within bar segments, g/cm^3) are apparent with increasing intensity and frequency of use (source: Halfpenny and Ozanne 1989).

Effects on thermal regimes

Snow compaction due to winter recreation activities strongly affects snow thermal characteristics. Increases in snow density can alter the thermal regime of underlying soils (Keddy et al. 1979, Fahey and Wardle 1998, Fahey et al. 1999). Thermal conductivity, defined as the rate at which heat energy passes through a given area, increases in proportion to the square of snow density (Kattelmann 1985, Fahey et al. 1999, Balland and Arp 2005). Temperature gradients were reduced by the passage of snowmobiles, extending subfreezing temperatures deep into soil profiles in studies in Wisconsin and Quebec (Figure 2) (Neumann and Merriam 1972, Pesant 1987).

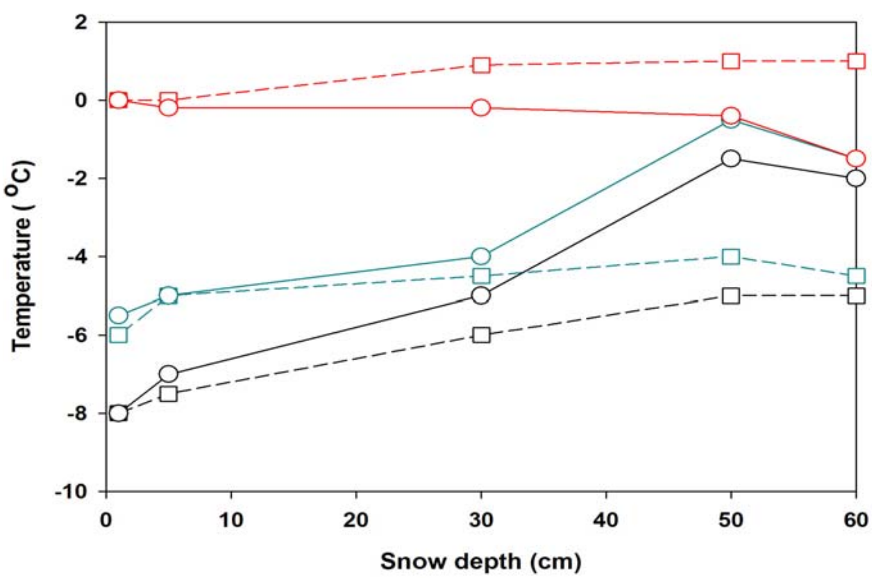

Figure 2 . Temperatures in snow profiles exposed to snowmobiling (squares, dashed lines) and controls (circles, solid lines) at three ambient air temperatures, black lines -8 ^{o}C, blue lines -6.0 ^{o}C, red lines -3.5 ^{o}C (reproduced from Neumann and Merriam 1972).

Soil temperatures in fens in southwest Colorado under alpine ski runs were different at both the soil surface and 20 cm below the soil surface, and soils under ski tracks remained significantly colder until the end of July than controls (Cooper and Chimner *Unpublished data*). Baiderin (1978) found that soil temperatures under snow on ski slopes can be 5–7 times colder and frost penetration 7–11 times higher than under non-skied snow (Baiderin 1978). Once compacted, snow is less susceptible to redistribution by wind (Fahey et al. 1999). Ski slope grooming caused a four-week delay in snow melt and soil warming (Keller et al. 2004).

Effects on soil and water chemistry

Vehicles of any sort, particularly two-stroke engines, can affect air, soil, and water chemistry. The effects of snowmobiles on air and water chemistry was investigated in Yellowstone National Park during the park's snowmobile management planning (Ingersoll et al. 1997, Olliff et al. 1999, Sive et al. 2003). Snowmobile emissions from two-stroke engines contributed large quantities of volatile organic compounds (VOCs) such as toluene and ethene, ozone (O_3), nitric oxide (NO), particulate matter (CN), carbon monoxide (CO), and methane (CH_4) into airsheds (Sive et al. 2003). Emissions can contribute to ground-level ozone formation and photochemical smog (Sive et al. 2003). High ozone can damage plants and present a health concern for humans and wildlife (Pleijel and Danielsson 1997, Trombulak and Frissell 2000, Arbaugh et al. 2003). Pollutants and dust can significantly reduce the albedo, increasing melting rates (McCarthy 2007).

The spatial pattern of pollutants varies in response to machine use and local atmospheric conditions. Mixing ratios of pollutants were found to decrease with increasing distance from the nearest road, and with still surface conditions, dilution of emissions is slow (Sive et al. 2003). Snow conditions can play an important role in influencing levels of snowmobile traffic, affecting the spatial patterns of emissions. Other meteorological effects such as boundary layer depth can influence the mixing ratios of emissions and allow the buildup of pollutants (Sive et al. 2003).

Vehicles may also lose fuel and other fluids onto the snow surface. Fluid emissions are generally lower in snowmobiles than automobiles since the introduction of wet-sump lubrication systems; however, snowmobiles may still discharge significant amounts of unburned fuel through tail pipe emissions (Bluewater Network 2002, Baker and Buthmann 2005). The pollutants contributed through fluid loss will vary depending on the number of machines, as well as machine age and condition. Site-specific impacts due to vehicle emissions may exacerbate regional increases in the deposition of pollutants

(Fenn et al. 1998, Baron et al. 2000, Fenn et al. 2003), although we found no specific research addressing the issue.

Snow and water chemistry may also be impacted as part of management for alpine skiing. For example, resorts may apply salts such as sodium chloride, calcium chloride, urea, or ammonium nitrate to alter snow physical properties and improve skiing conditions. Salting ski runs is often done for slalom races, for example, to ensure similar coarse conditions for early and late racers. While there are no specific studies examining effects on wetlands, impacts to water quality could be significant given that many wetlands receive water from affected slopes.

Effects on hydrologic processes

Compression of snow from recreation impacts reduces snow permeability, porosity, and water holding capacity, affecting the rate of runoff and soil thawing in spring (Neumann and Merriam 1972, Fahey and Wardle 1998). Compared to controls, snow tracks affected by snow grooming increased snow water content by 62% and 84% in early and late-winter snow packs, respectively (Fahey et al. 1999). Snow compaction by snowmobiles can nearly increase melting times and snowpack duration (Neumann and Merriam 1972, Kattelmann 1985). Soil in a fen under ski tracks at the Telluride Ski area in the San Juan Mountains froze and remained colder than the ambient plots for up to two months (Cooper and Chimner *Unpublished data*). As with soil temperature, snow water holding capacity, defined as the ability of snow to retain added water, is reduced throughout the snowpack due to a reduction of pore space. Neumann and Merriam (1972) reported a nearly 40% reduction in water holding capacity in snowpacks impacted by snowmobiling; however, total water content per unit volume of snow is greater because of higher snow density. The greatest increase in snow density occurs as a result of the initial vehicle pass (Keddy et al. 1979).

Net changes to hydrologic processes vary based on a number of factors. Snow compaction within wetlands is a direct impact altering basic hydrologic processes such as snowmelt-derived runnoff rates. The magnitude of hydrologic changes can be expected to increase as the extent of compaction increases. Cumulative hydrologic effects in contributing watersheds can also be important, and are also likely to increase in relation to the proportion of the watershed impacted (Winter 1988, Brinson 1988, Siegel 1988).

Wetland type may be an important variable influencing the magnitude of hydrologic response to winter recreation activities. Differences in underlying hydrologic regime among wetland types provide important context for predicting the likely effects from on-site and cumulative watershed impacts. For example, because many fens are supported by large and stable contributing aquifers, they are less likely to be affected by changes in melting rates in contributing watersheds due to compaction than wetlands with surface water regimes such as marshes. However, we found no data specifically contrasting the response of different wetland types to changes in snow properties from winter recreation.

Effects on soils

Impacts to soils from winter recreation include those related to physical structure, microbial communities, and soil chemistry (Neumann and Merriam 1972, Caissie 1999). The magnitude of the effect will vary widely depending on the nature of the activity and snow pack characteristics. Effects should be greater where use is more intense and frequent. Among common winter recreation activities, alpine skiing likely has the greatest impact on soils, although we found few studies examining soil impacts from nonmotorized activities. In general, soils are most vulnerable to direct impacts when snowpacks are thin or patchy (Felix and Raynolds 1989).

Direct soil compaction from heavy machinery can decrease soil volume, soil aeration, and porosity, damaging plant roots (Nadezhdina et al. 2006). For example, in Alaska, the passage of tracked-vehicles over partially melted Arctic tundra modified topography and vegetation with the greatest impacts in the wettest moisture regime and least in the driest (Gersper and Challinor 1975). In a European study, soils of ski runs significantly less organic carbon (-34%, -11.9 +/- 3.6 t/ha) and micropore volume and size (-33%, -0.07 +/- 0.01 cm^3/cm^{-3} and -48%, -1.62 +/- 0.28 µm) when compared to soils in control areas (Delgado et al. 2007). However, direct soil compaction from most winter recreation activities is not likely an important impact, as even moderate snow buffers the effects of soil compaction (Argow and Fitzgerald 2006). Increased soil freezing, higher snowpack density, and later melt-out could affect wetlands by compressing peat, altering microtopography in areas (Argow and Fitzgerald 2006).

Colder temperatures reduce the activity of plant roots and soil microorganisms, which can affect basic ecological processes such as soil respiration and plant productivity. Compaction of the snow cover by grooming can reduce the abundance of the whole soil fauna by approximately 70% (Meyer 1993). Effects can also include large reductions in soil bacteria and fungi under compacted snowmobile tracks, due largely to the effects of reduced soil temperatures (Neumann and Merriam 1972, Price 1985, Fahey et al. 1999) . In Europe, altered thermal characteristics and reduced micropore volume due to management for alpine skiing has been shown to dramatically reduce the density of fungal hyphae when compared to control sites (Delgado et al. 2007). We found no specific studies examining how such alterations may affect the fens or wetlands specifically, but are possible because of the importance of decomposition to the carbon balance of peatlands.

Not all studies have found lower soil temperatures under altered snowpacks. For example, although Keller et al. (2004) found greater snow density, hardness, and thermal conductivity on ski slopes versus controls, soil temperatures were not significantly different, which the authors attributed to moderate air temperatures during their study (Keller et al. 2004). It is likely that the impacts of different recreation activities on soil temperature vary as a function of the original snowpack depth and degree of compaction. Low intensity snowshoeing, for example, is less likely to affect soil temperatures then regular grooming as part of the maintenance of alpine ski runs.

Effects on vegetation

The general effects of soil compaction on soils and vegetation is well documented in the literature (Kozlowski 1999), although few studies examining the effects of snow compaction have been conducted, particularly in wetlands. Adverse effects have been demonstrated in a variety of plant communities (Greller et al. 1974, Keddy et al. 1979, Sanecki et al. 2006b). Direct mechanical injury to plants can occur, particularly where snow cover is thin. The most vulnerable plants to direct damage by vehicles are trees and shrubs (Neumann and Merriam 1972, Emers et al. 1995). Snow compaction can promote the formation of soil frost and ice layers and delay plant development (Rixen et al. 2003).

Soil compaction can alter soil structure by increasing soil bulk density, breaking down soil aggregates, reducing soil porosity, aeration, and infiltration capacity (Whitecotton et al. 2000, Kozlowski 2000, Thurston and Reader 2001, Keller et al. 2004, Nadezhdina et al. 2006). These soil effects can influence the physiological performance of plants by altering amounts and balances of growth hormones such as abscisic acid and ethylene, reducing total photosynthesis and productivity as a result of the smaller leaf area (Kozlowski 1999). Again, it is likely that the degree of impact from soil compaction is generally small where snowpacks are deep enough to buffer the weight of passing vehicles. The specific snow depth required to ensure no appreciable impacts to underlying vegetated surfaces is likely highly variable and is unknown for wetlands and fens.

Natural vegetation patterns in alpine and subalpine environments are strongly influenced by snow distribution (Billings and Bliss 1959, Kuramoto and Bliss 1970, Galen and Stanton 1995). Redistribution of snow by wind is a key natural process influencing the spatial patterning of snow depth and is strongly influenced by topography. Any activity that alters the size, thickness, or location of snow banks can affect vegetation beneath and downgradient from it. Although the effects of snowmobiling, cross-country skiing, or snowshoeing on the landscape scale patterns of snowpack distribution are likely quite small, these activities do have the potential to affect snow distribution at finer spatial scales.

Ski run grooming and use can thin and compress snow cover subjecting plants to colder temperatures. Species lacking sufficient cold hardiness may be at a competitive disadvantage, leading to shifts among plant functional groups or an increase in unvegetated ground (Fahey et al. 1999, Pickering and Hill 2003, Rixen et al. 2003, Keller et al. 2004). Where use is significant, similar impacts may be expected from snowmobile use. For example, in an analysis of data from Wanek (1974), Keddy found that early spring plants were significantly smaller and less frequent under snowmobile trails, although Keddy et al (1979) did not specifically identify the affected species.

The impact of winter recreation activities can affect plant populations (Figure 3). Ski grooming may affect vegetation by changing soil seed banks. Machine graded ski slopes in the Swiss Alps had more species-poor seed banks than non-graded sites (Urbanska et al. 1998, Urbanska and Fattorini 1998a, Urbanska and Fattorini 1998b, Urbanska et al. 1999, Urbanska and Fattorini 2000). Plant communities can also be impacted through effects on plant establishment and recruitment due to seedling and sampling mortality (Kozlowski 1999). Some species may also have their phenological patterns altered, for example later blooming of spring perennials (Baiderin 1978).

Reduced species cover and diversity occurs even on older, less heavily impacted alpine ski slopes in Washington State (Titus and Tsuyuzaki 1998). However, predicting species level responses to altered snowpack is difficult. Clonal grasses and sedges may be more resilient than plants with other life forms (Foresman et al. 1976). The tolerance of plants can be affected by plant structure, potential for recovery, and environmental conditions, as well as the disturbance intensity and frequency (Liddle 1997, Gallet et al. 2004). For example, the proportion of summer-flowering plants was reduced in ski slopes relative to control plots in Russia, with the exception of the rhizomatous *Poa pratensis,* which expanded its cover (Baiderin 1978).

Distance to gravel surface roads on ski runs, ski run width, distance to forest edge, and the amount of soil compaction were among the most important factors influencing vegetation in ski slope plant communities in southern Nevada (Titus and Landau 2003). Machine grading reduced woody plant cover and productivity between graded ski slopes and control areas (Wipf et al. 2005). Given the more severe disturbances associated with alpine skiing, these results may be more severe than impacts from cross-country skiing and possibly from snowmobiling.

The response of vascular plant species and non-vascular plants like mosses may differ. Experimental trampling in a European study found that vascular plant cover declined immediately after trampling, while bryophytes had a slower response to this treatment.

However, vascular species recovered more rapidly than bryophytes (Torn et al. 2006). Whether similar responses occur in response to winter recreation impacts is unknown.

In fens, it is important to recognize that plant growth is not just in summer. New shoots emerge from soil in winter under snow. Sedges have special winter leaves that are evergreen, while other species have pre-formed buds near ground surface and flower before leaves emerge. Much of the summer growth occurs in the 2-4 weeks after snowmelt and there may be little or no sexual reproduction. Many species are clonal and may be of great age.

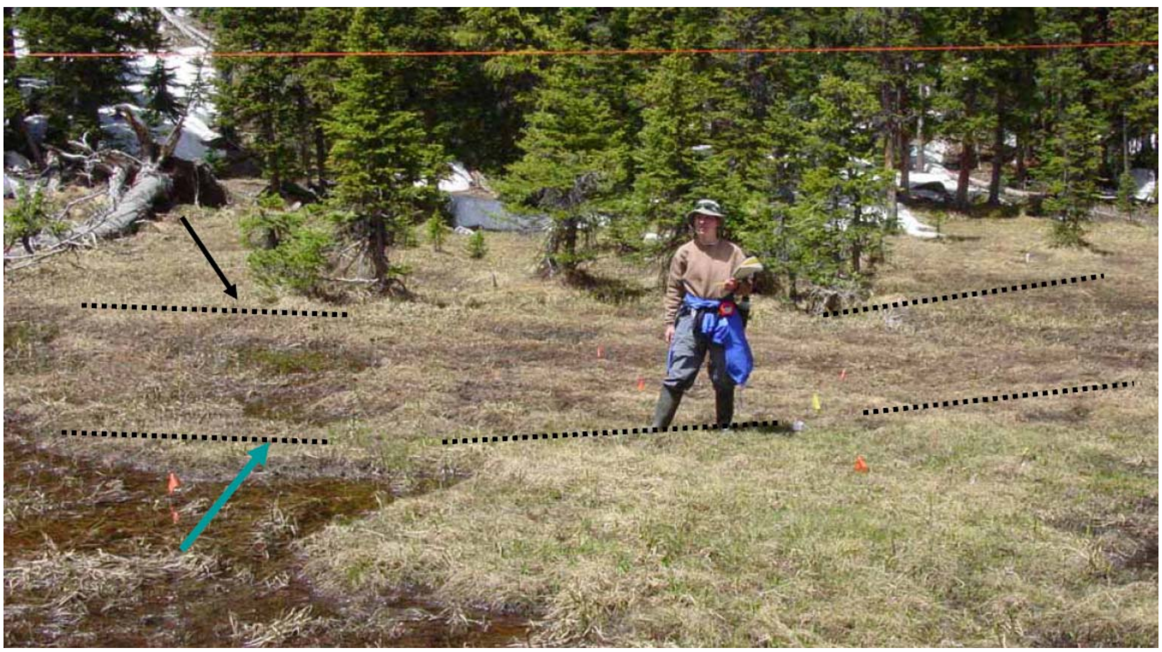

Figure 3. Altered vegetation in a groomed ski run visible by difference in vegetation color between impacted areas (areas between dashed lines) and control areas. Dashed lines and arrows indicate boundary of groomed area.

Effects on fauna

The subnivean space between the ground surface and base of the snowpack is critical for the survival of many small mammals (Sanecki et al. 2006a, Sanecki et al. 2006b). Colder temperatures in the subnivean space may reduce winter survival of small mammals and arthropods. Microtopographic features such as shrubs, saplings, and boulders are able to support the weight of the snowpack above the ground, and the loss of these features due to compaction can reduce subnivean space (Halfpenny and Ozanne 1989, Sanecki et al.

2006b). A reduction in subnivean space may deleteriously affect small mammals by reducing their ability to travel, forage, and access food caches (Benedict and Benedict 2001). Impacts to small mammals vary in relation to spatial extent and severity of snow compaction.

Richness and abundance of arthropods was significantly lower in groomed ski runs than in other plot types in one study, reducing food availability to dependent bird species (Rolando et al. 2007). As with many of the other responses discussed in this review, the severity of impacts to wetland fauna varies as a function of wetland type and the intensity, frequency, and spatial extent of use.

Additional impacts to wildlife such as deer and elk have been identified, including increased wildlife stress due to noise, and altered animal movements and competitive interactions from the creation of tracks (Olliff et al. 1999, Sive et al. 2003, Kolbe et al. 2007, McCarthy 2007). Compounds commonly found in snowmobile emissions were experimentally found to reduce the swimming stamina of brook trout (Adams 1975). Noise from snowmobiles has been associated with elevated levels of stress hormones in wildlife (Olliff et al. 1999).

Effects on ecosystem properties

In a fen within the Telluride Ski area in Colorado, the rate of photosynthesis and net ecosystem exchange (NEE) of CO_2 were lower during early summer in ski runs when compared to adjacent control areas. Average gross primary productivity and NEE rates for the entire growing season were lower in the ski track compared to controls (Cooper and Chimner *Unpublished data*). These changes were apparently caused by lower winter and early summer soil temperatures which slowed plant growth. The long-term implications of these changes are unknown, but could include species changes, and loss of peat. Increased nutrient availability to vegetation has been observed on ski runs, particularly graded ones, when compared to controls (Wipf et al. 2005).

The long-term changes in plant productivity, organic matter decomposition rates, and peat accumulation processes due to winter recreation are unknown. Peat accumulation rates in Rocky Mountain fens are exceedingly slow, approximately 20 cm (8 inches) per thousand years (Chimner et al. 2002, Chimner and Cooper 2003) and are very sensitive to changes in hydrologic regime. Altered soil temperature regimes may lower plant production in fens, lowering production and carbon gain by reducing the amount of carbon entering the wetland. Changes in basin-wide melt-out of snowpacks due to compaction may not significantly impact hydrologic function in groundwater supported fens, but snow compaction on-site may reduce the length of the growing season which is important for high-elevation plants.

Acute versus cumulative effects

The intensity, frequency, and extent of winter recreation activities differ from site to site, which influences ecological impacts. Alpine skiing operations represent the most intense and frequent impacts; however, on an aerial basis, operations are limited when compared to cross-country skiing or snowmobiling. Thus, it is important to define the area and timeframe of interest when attempting to assess impacts from different winter recreation activities.

With sufficient intensity and frequency, even nonmotorized activities within wetlands may alter snow properties, with localized effects to vegetation and soils. There are likely thresholds of impact that vary by wetland and vegetation type, and intensity and frequency of use. Unfortunately, there are insufficient data to identify potential impact thresholds for particular snow conditions.

Individual anthropogenic impacts may act synergistically on watershed processes (Siegel 1988, Winter 1988, Reid 1993, Bedford 1999). The cumulative effects of winter recreation activities in a given watershed may result in greater hydrologic and ecological changes than expected by simply summing the contributions of each individual stressor. As with acute effects, cumulative effects of winter recreation activities likely differ by wetland and vegetation type.

Conclusions

Limited information on the impacts of winter recreation on snowpack properties, vegetation, soils, and fauna has been published, and very few studies have examined impacts to the wetland types that occur in the Rocky Mountain region. Thus, the factors driving ecological response to winter recreation are poorly understood.

In general, there is insufficient information from which to identify specific management thresholds from impacts to fens and wetlands from winter recreation activities. Many of the potential impacts have only been speculated or noted anecdotally. However, there is sufficient information in the scientific literature to make general assessments of potential impacts. Alterations of the physical properties of snowpacks, generally far easier to document than changes in soil microbial communities, have been well described. A summary of some key points follows:

- Winter recreation impacts can be direct or indirect with respect to a particular resource; direct effects to soil and vegetation resources (e.g. direct mortality due to mechanical damage) are likely of less importance than indirect effects.

- Winter recreation activities vary widely in intensity and extent of impact. Intermittent or occasional impacts (e.g. off-trail snowshoeing in wilderness) will likely have a negligible effect on wetland resources. More sustained and extensive impacts, for example, as from operations associated with alpine skiing, are more likely to affect wetlands.

- Physical and chemical changes can potentially affect biota through alteration of habitat characteristics. Vulnerability of specific taxa will vary. Altered ecological conditions may lead to shifts in community composition, diversity, or structure, although studies specific to wetlands are generally lacking.

- Plant production and decomposition are elemental processes governing ecosystem structure and function in wetlands; alterations of soil thermal and hydrologic properties from winter recreation activities may change basic ecosystem function by altering decomposition rates and production.

- Fens are sensitive to changes in hydrologic regime; alteration of hydrologic flow paths may change basic ecological processes such as decomposition.

More information is needed comparing the impacts of different recreation activities on key hydrologic and ecological processes. This is particularly true if accurate models of snow depth and specific impacts are desired for management. Few such data are available for the Rocky Mountain region, with a large proportion of studies originating in other regions and continents.

An improved understanding of watershed-scale distribution, frequency, and intensity of winter recreation use is needed to evaluate potential impacts to wetland resources. Combined with wetland inventory data and occurrence records of rare species or noteworthy ecological communities, wetlands with exceptionally high conservation value, such as fens supporting rare species, can be identified and addressed in planning and management.

Literature cited

Adams, E. S. 1975. Effects of lead and hydrocarbons from snowmobile exhaust on brook trout (*Salvelinus fontanlis*). Transactions of the American Fisheries Society 104: 363-373.

Arbaugh, M., A. Bytnerowicz, N. Grulke, M. Fenn, M. Poth, P. Temple, and P. Miller. 2003. Photochemical smog effects in mixed conifer forests along a natural gradient of ozone and Nitrogen deposition in the San Bernardino Mountains. Environment International 29: 401-406.

Argow, B. A. and D. M. Fitzgerald. 2006. Winter processes on northern salt marshes: evaluating the impact of in-situ peat compaction due to ice loading, Wells, ME. Estuarine Coastal and Shelf Science 69: 360-369.

Baiderin, V. V. 1978. Effect of winter recreation on soil and vegetation of slopes in vicinity of Kazan. Soviet Journal of Ecology 9: 76-80.

Baker, E. and E. Buthmann. 2005. Snowmobiling in the Adirondack Park: Environmental and Social Impacts. St. Lawrence University, Department of Biology, Canton, NY.

Balland, V. and P. A. Arp. 2005. Modeling soil thermal conductivities over a wide range of conditions. Journal of Environmental Engineering and Science 4: 549-558.

Baron, J. S., N. L. Poff, P. L. Angermeier, C. N. Dahm, P. H. Gleick, N. G. Hairston, R. B. Jackson, C. A. Johnston, B. D. Richter, and A. D. Steinman. 2002. Meeting ecological and societal needs for freshwater. Ecological Applications 12: 1247-1260.

Baron, J. S., H. M. Rueth, A. M. Wolfe, K. R. Nydick, E. J. Allstott, J. T. Minear, and B. Moraska. 2000. Ecosystem responses to Nitrogen deposition in the Colorado Front Range. Ecosystems 3: 352-368.

Bedford, B. L. 1999. Cumulative effects on wetland landscapes: links to wetland restoration in the United States and southern Canada. Wetlands 19: 775-788.

Bedford, B. L. and K. S. Godwin. 2003. Fens of the United States: distribution, characteristics, and scientific connection versus legal isolation. Wetlands 23: 608-629.

Benedict, J. B. and A. D. Benedict. 2001. Subnivean root caching by a montane vole (*Microtus montanus nanus*), Colorado Front Range, USA. Western North American Naturalist 61: 241-244.

Billings, W. D. and L. C. Bliss. 1959. An alpine snowbank environment and its effects on vegetation, plant development, and productivity. Ecology 40: 388-397.

Bluewater Network. 2002. Snowmobile Position Paper. Available at: www.bluewaternetwork.org/reports/rep_pl_snow_snowposition.pdf.

Boyer, T. and S. Polasky. 2004. Valuing urban wetlands: a review of non-market valuation studies. Wetlands 24: 744-755.

Brinson, M. M. 1988. Strategies for assessing the cumulative effects of wetland alteration on water quality. Environmental Management 12: 655-662.

Brinson, M. M. and A. I. Malvarez. 2002. Temperate freshwater wetlands: types, status, and threats. Environmental Conservation 29: 115-133.

Caissie, A. 1999. Effects of snowmobile traffic on the vegetation of a coastal plain Sphagnum bog in Gros Morne National Park, western Newfoundland . 133 p., The University of New Brunswick (Canada).

Challinor, J. L. and P. L. Gersper. 1975. Vehicle perturbation effects upon a tundra soil-plant system 2. Effects on chemical regime. Soil Science Society of America Journal 39: 689-695.

Chapin, F. S. and G. R. Shaver. 1981. Changes in soil properties and vegetation following disturbance of Alaskan Arctic tundra. Journal of Applied Ecology 18: 605-617.

Chimner, R. A. and D. J. Cooper. 2003. Carbon dynamics of pristine and hydrologically modified fens in the southern Rocky Mountains. Canadian Journal of Botany 81: 477-491.

Chimner, R. A., D. J. Cooper, and W. J. Parton. 2002. Modeling carbon accumulation in Rocky Mountain fens. Wetlands 22: 100-110.

Colbeck, S. C. 1982. An overview of seasonal Snow metamorphism. Reviews of Geophysics 20: 45-61.

Cole, D. N. 1995. Disturbance of natural vegetation by camping - experimental applications of low-level stress. Environmental Management 19: 405-416.

Cole, D. N. and C. A. Monz. 2003. Impacts of camping on vegetation: response and recovery following acute and chronic disturbance. Environmental Management 32: 693-705.

Cole, D. N. and C. A. Monz. 2004. Spatial patterns of recreation impact on experimental campsites. Journal of Environmental Management 70: 73-84.

Cooper, D. J. and R. Chimner. *Unpublished data*.

Deems, J. S. 2007. Quantifying scale relationships in snow distribution. 125 p., Colorado State University, Geosciences Department. Fort Collins, CO.

Delgado, R., M. Sanchez-Maranon, J. M. Martin-Garcia, V. Aranda, F. Serrano-Bernardo, and J. L. Rosua. 2007. Impact of ski pistes on soil properties: a case study from a mountainous area in the Mediterranean region. Soil Use and Management 23: 269-277.

Dunne, T. and L. B. Leopold. 1978. Water in Environmental Planning. 1st ed. W.H. Freeman and Company. New York, NY. 818 pp.

Emers, M., J. C. Jorgenson, and M. K. Raynolds. 1995. Response of Arctic tundra plant-communities to winter vehicle disturbance. Canadian Journal of Botany 73: 905-917.

Environmental Laboratory. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Fahey, B. and K. Wardle. 1998. Likely impacts of snow grooming and related activites in the West Otago ski fields. Department of Conservation, Wellington, New Zealand.

Fahey, B., K. Wardle, and P. Weir. 1999. Environmental effects associated with snow grooming and. skiing at Treble Cone Ski Field.

Felix, N. A. and M. K. Raynolds. 1989. The role of snow cover in limiting surface disturbance caused by winter seismic exploration. Arctic 42: 62-68.

Felix, N. A., M. K. Raynolds, J. C. Jorgenson, and K. E. Dubois. 1992. Resistance and resilience of tundra plant-communities to disturbance by winter seismic vehicles. Arctic and Alpine Research 24: 69-77.

Fenn, M. E., J. S. Baron, E. B. Allen, H. M. Rueth, K. R. Nydick, L. Geiser, W. D. Bowman, J. O. Sickman, T. Meixner, D. W. Johnson, and P. Neitlich. 2003. Ecological effects of nitrogen deposition in the western United States. Bioscience 53: 404-420.

Fenn, M. E., M. A. Poth, J. D. Aber, J. S. Baron, B. T. Bormann, D. W. Johnson, A. D. Lemly, S. G. Mcnulty, D. E. Ryan, and R. Stottlemyer. 1998. Nitrogen excess in North American ecosystems: predisposing factors, ecosystem responses, and management strategies. Ecological Applications 8: 706-733.

Foresman, C. L., D. K. Ryerson, R. N. Walejko, W. H. Paulson, and J. W. Pendleton. 1976. Effect of snowmobile traffic on bluegrass (*Poa pratensis*). Journal of Environmental Quality 5 : 129-130.

Gage, E. A. and D. J. Cooper. 2006. *Carex diandra* Schrank (lesser panicled sedge): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region, Lakewood, CO. http://www.fs.fed.us/r2/projects/scp/assessments/carexdiandra.pdf.

Galen, C. and M. L. Stanton. 1995. Responses of snowbed plant species to changes in growing-season length. Ecology 76: 1546-1557.

Gallet, S., S. Lemauviel, and F. Roze. 2004. Responses of three heathland shrubs to single or repeated experimental trampling. Environmental Management 33: 821-829.

Gersper, P. L. and J. L. Challinor. 1975. Vehicle perturbation effects upon a tundra soil-plant system .1. Effects on morphological and physical environmental properties of soils. Soil Science Society of America Journal 39: 737-744.

Greller, A. M., M. Goldstein, and L. Marcus. 1974. Snowmobile impact on three alpine tundra plant communities. 1: 101-110.

Halfpenny, J. C. and R. D. Ozanne. 1989. Winter: An Ecological Handbook. Johnson Books. Boulder, CO.

Harper, K. A. and G. P. Kershaw. 1996. Natural revegetation on borrow pits and vehicle tracks in shrub tundra, 48 years following construction of the Canol no. 1 pipeline, NWT, Canada. Arctic and Alpine Research 28: 163-171.

Heegaard, E. 2002. A model of alpine species distribution in relation to snowmelt time and altitude. Journal of Vegetation Science 13: 493-504.

Ingersoll, G. et al. 1997. Snowpack chemistry as an indicator of pollutant emission levels from motorized winter vehicles in Yellowstone National Park. *In:* Proceedings of 65th Annual Meeting of Western Snow Conference. Banff, Alberta,

Kattelmann, R. 1985. Snow compaction effects on night-time freezing. Proceedings of the Western Snow Conference 56: 168-171.

Keddy, P. A., A. J. Spavold, and C. J. Keddy. 1979. Snowmobile impact on old field and marsh vegetation in Nova Scotia, Canada: an experimental study. Environmental Management 3: 409-415.

Keller, T., C. Pielmeier, C. Rixen, F. Gadient, D. Gustafsson, and M. Stahli. 2004. Impact of artificial snow and ski-slope grooming on snowpack properties and soil thermal regime in a sub-alpine ski area. Annals of Glaciology 38: 314-318.

Kevan, P. G., B. C. Forbes, S. M. Kevan, and V. Behanpelletier. 1995. Vehicle tracks on high Arctic tundra - their effects on the soil, vegetation, and soil arthropods. Journal of Applied Ecology 32: 655-667.

Kolbe, J. A., J. R. Squires, D. H. Pletscher, and L. F. Ruggiero. 2007. The effect of snowmobile trails on coyote movements within lynx home ranges. Journal of Wildlife Management 71: 1409-1418.

Kozlowski, T. T. 1999. Soil compaction and growth of woody plants. Scandinavian Journal of Forest Research 14: 596-619.

Kozlowski, T. T. 2000. Responses of woody plants to human-induced environmental stresses: issues, problems, and strategies for alleviating stress. Critical Reviews in Plant Sciences 19: 91-170.

Kuramoto, R. T. and L. C. Bliss. 1970. Ecology of subalpine meadows in the Olympic Mountains, Washington. Ecological Monographs 40: 317-347.

Leung, Y. F. and J. L. Marion. 1999. Characterizing backcountry camping impacts in Great Smoky Mountains National Park, USA. Journal of Environmental Management 57: 193-203.

Liddle, M. 1997. Recreation Ecology: The Ecological Impact of Outdoor Recreation and Ecotourism. Springer. New York, NY.

MacDonald, L. H. 2000. Evaluating and managing cumulative effects: process and constraints. Environmental Management 26: 299-315.

Marion, J. L. and D. N. Cole. 1996. Spatial and temporal variation in soil and vegetation impacts on campsites. Ecological Applications 6: 520-530.

Marion, J. L. and T. A. Farrell. 2002. Management practices that concentrate visitor activities: camping impact managment at Isle Royale National Park, USA. Journal of Environmental Management 66: 201-212.

McCarthy, J. E. 2007. CRS Report for Congress, Snowmobiles: Environmental Standards and Access to National Parks. RL31149. Congressional Research Service, Library of Congress, Washington D.C.

Meyer, E. 1993. The impact of summer tourism and winter tourism on the fauna of alpine soils in western Austria (Oetztal Alps, Ratikon). Revue Suisse De Zoologie 100: 519-527.

Nadezhdina, N., J. Cermak, J. Neruda, A. Prax, R. Ulrich, V. Nadezhdin, J. Gasparek, and E. Pokorny. 2006. Roots under the load of heavy machinery in spruce trees. European Journal of Forest Research 125: 111-128.

Neumann, P. W. and H. G. Merriam. 1972. Ecological effects of snowmobiles. Canadian Field-Naturalist 86: 207-212.

Office of Technology Assessment. 1984. Wetlands: Their Use and Regulation. U.S. Congress OTA-O-206. U.S. Congress, Washington, D.C.

Olliff, T., K. Legg, and B. Kaeding. 1999. Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Patten, D. T. 1998. Riparian ecosystems of semi-arid North America: Diversity and human impacts. Wetlands 18: 498-512.

Pesant, A. R. 1987. Snowmobiling impact on soil properties and winter cereal crops 101: 22-32.

Pickering, C. and H. Hill. 2003. Pages 137-150 Nature-based Tourism, Environment and Land Management. CABI Publishing

Pickering, C. M., J. Harrington, and G. Worboys. 2003. Environmental impacts of tourism on the Australian Alps protected areas - judgments of protected area managers. Mountain Research and Development 23: 247-254.

Pleijel, H. and H. Danielsson. 1997. Growth of 27 herbs and grasses in relation to ozone exposure and plant strategy. New Phytologist 135: 361-367.

Price, M. F. 1985. Impacts of recreational activities on alpine vegetation in western North America. Mountain Research and Development 5: 263-277.

Reid, L. M. 1993. Research and Cumulative Watershed Effects. General Technical Report PSW-141. USDA Forest Service, Pacific Southwest Research Station, Albany, CA.

Rixen, C., V. Stoeckli, and W. Ammann. 2003. Does artificial snow production affect soil and vegetation of ski pistes? a review. Perspectives in Plant Ecology Evolution and Systematics 5: 219-230.

Rolando, A., E. Caprio, E. Rinaldi, and I. Ellena. 2007. The impact of high-altitude ski runs on alpine grassland bird communities. Journal of Applied Ecology 44: 210-219.

Ryerson, D. K., D. A. Schlough, C. L. Foresman, G. H. Tenpas, and J. W. Pendleton. 1977. Effects of snowmobile traffic on several forage species and winter-wheat. Agronomy Journal 69: 769-772.

Sanecki, G. M., A. Cowling, K. Green, H. Wood, and D. Lindenmayer. 2006a. Winter distribution of small mammals in relation to snow cover in the subalpine zone, Australia. Journal of Zoology 269: 99-110.

Sanecki, G. M., K. Green, H. Wood, and D. Lindenmayer. 2006b. The implications of snow-based recreation for small mammals in the subnivean space in south-east Australia. Biological Conservation 129: 511-518.

Siegel, D. I. 1988. Evaluating cumulative effects of disturbance on the hydrologic function of bogs, fens, and mires. Environmental Management 12: 621-626.

Sive, B., D. Shively, B. Pape, K. Carpemter, R. Griffin, R. N. Mowe, R. Russo, E. Scheur, Y. Zhou, and O. Wingenter. 2003. Spatial Variation of Volatile Organic

Compounds Associated With Snowmobile Emissions in Yellowstone National Park . 2003, http://www.nps.gov/yell/parkmgmt/upload/sive_report.pdf.

Sutherland, R. A., J. O. Bussen, D. L. Plondke, B. M. Evans, and A. D. Ziegler. 2001. Hydrophysical degradation associated with hiking trail use: a case study of Hawai'iloa Ridge Trail, O'ahu, Hawai'i. Land Degradation & Development 12: 71-86.

Thurston, E. and R. J. Reader. 2001. Impacts of experimentally applied mountain biking and hiking on vegetation and soil of a deciduous forest. Environmental Management 27: 397-409.

Tiner, R. W. 1984. Wetlands of the United States current status and recent trends. National Wetlands Inventory, Fish and Wildlife Service, U.S. Dept. of the Interior. For sale by the Supt. of Docs., U.S. G.P.O. Washington, D.C. 59 pp.

Tiner, R. W. 1999. Wetland Indicators : A Guide to Wetland Identification, Delineation, Classification, and Mapping. Lewis Publishers. Boca Raton, FL.

Titus, J. H. and F. Landau. 2003. Ski slope vegetation of Lee Canyon, Nevada, USA. Southwestern Naturalist 48: 491-504.

Titus, J. H. and S. Tsuyuzaki. 1998. Ski slope vegetation at Snoqualmie Pass, Washington State, USA, and a comparison with ski slope vegetation in temperate coniferous forest zones. Ecological Research 13: 97-104.

Torn, A., J. Rautio, Y. Norokorpi, and A. Tolvanen. 2006. Revegetation after short-term trampling at subalpine heath vegetation. Annales Botanici Fennici 43: 129-138.

Trombulak, S. C. and C. A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14: 18-30.

Urbanska, K. M., S. Erdt, and M. Fattorini. 1998. Seed rain in natural grassland and adjacent ski run in the Swiss Alps: a preliminary report. Restoration Ecology 6: 159-165.

Urbanska, K. M. and M. Fattorini. 1998a. Seed bank studies in the Swiss Alps. I. Un-restored ski run and the adjacent intact grassland at high elevation. Botanica Helvetica 108: 93-104.

Urbanska, K. M. and M. Fattorini. 1998b. Seed bank studies in the Swiss Alps - II. Restoration plots on a high-alpine ski run. Botanica Helvetica 108: 289-301.

Urbanska, K. M. and M. Fattorini. 2000. Seed rain in high-altitude restoration plots in Switzerland. Restoration Ecology 8: 74-79.

Urbanska, K. M., M. Fattorini, K. Thiele, and K. Pflugshaupt. 1999. Seed rain on alpine ski runs in Switzerland. Botanica Helvetica 109: 199-216.

USFS. 2001. National Forest System Lands Aquatic and LRMP Standards and Guidelines and Watershed Conservation Practices Handbook. USDA Forest Service, Medicine Bow and Routt National Forests, Laramie, WY.

USFS. 2002. Memo 2070/2520-7/2620, signed by the Region 2 Director of Renewable Resources March 19, 2002. USDA Forest Service, Rocky Mountain Region, Lakewood, Colorado.

USFS. 2007. Forest Service Manual, Rocky Mountain Region (Region 2), FSM 2600 - Wildlife, Fish, and Sensitive Plant Habitat, Chapter 2670 - Threatened, Endangered and Sensitive Plants and Animals, Supplement No. 2600-2007-1, 2672.11 - Exhibit 1, R2 Sensitive Species Plant List, Approved by Rick Cables, Regional Forester on June 8, 2007. USDA Forest Service, Rocky Mountain Region, Lakewood, CO.

Walker, D. A., J. C. Halfpenny, M. D. Walker, and C. A. Wessman. 1993. Long-term studies of snow-vegetation interactions. BioScience 43: 287-301.

Whitecotton, R. C. A., M. B. David, R. G. Darmody, and D. L. Price. 2000. Impact of foot traffic from military training on soil and vegetation properties. Environmental Management 26: 697-706.

Winter, T. C. 1988. A conceptual framework for assessing cumulative impacts on the hydrology of non-tidal wetlands. Environmental Management 12: 605-620.

Wipf, S., C. Rixen, M. Fischer, B. Schmid, and V. Stoeckli. 2005. Effects of ski piste preparation on alpine vegetation. Journal of Applied Ecology 42: 306-316.

Wolf, E., E. Gage, and D. J. Cooper. 2006. *Drosera rotundifolia* L. (roundleaf sundew): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region, http://www.fs.fed.us/r2/projects/scp/assessments/droserarotundifolia.pdf.

Xue, Y. K., S. F. Sun, D. S. Kahan, and Y. J. Jiao. 2003. Impact of parameterizations in snow physics and interface processes on the simulation of snow cover and runoff at several cold region sites. Journal of Geophysical Research-Atmospheres 108.