BOARD OF SUPERVISORS

TERRELL SWOFFORD, DISTRICT 1
KEVIN GOSS, DISTRICT 2
SHARON THRALL, DISTRICT 3
LORI SIMPSON, DISTRICT 4
JEFF ENGEL, DISTRICT 5

March 26, 2015

VIA E-MAIL AND PERSONAL DELIVERY

Peter Barnes
Engineering Geologist
State Water Resources Control Board,
Division of Water Rights
P.O. Box 2000
Sacramento, CA 95812-2000
E-Mail: Peter.Barnes@waterboards.ca.gov

Re: Upper North Fork Feather River Hydroelectric Project Draft Environmental Impact Report

To Whom it May Concern:

Plumas County ("County") appreciates the opportunity to provide comments regarding the Upper North Fork Feather River Hydroelectric Project Draft Environmental Impact Report, SCH No. 2005082122 ("EIR"). As detailed in the comments below, the County is concerned that the EIR is inadequate in many respects and therefore fails to serve its purposes under the California Environmental Quality Act ("CEQA"). The County objects to any decision by the State Water Resources Control Board ("State Board") based on the EIR until the EIR's numerous inadequacies have been corrected. The County submits this letter in the hope that the State Board will correct these deficiencies and provide responses to the County's questions and comments, so that the County, its residents, other members of the public, and the State Board can be fully informed regarding the decisions facing the State Board and related issues addressed in the EIR.

I. <u>The State Board Must Protect The Beneficial Cold Water And Recreational Uses At Lake Almanor</u>

A chief concern of the County is that the State Board is proposing, or at least contemplating, actions that the EIR admits will significantly impact the coldwater fishery in Lake Almanor. At the same time, the EIR admits that any benefit to the coldwater fishery and other beneficial uses in the lower North Fork Feather River will be minimal if they are detectable at all. The County maintains that under these circumstances the legal, social, and policy balance favors protecting beneficial uses at Lake Almanor. For these reasons, the Federal Energy Regulatory Commission's Final Environmental Impact Statement concluded "that structural or operational modifications to the Prattville intake that were evaluated would likely have detrimental effects on the coldwater fishery in Lake Almanor and Butt Valley reservoir, and would provide only limited benefit to the coldwater fish populations in Seneca and Belden reaches of the UNFFR and even less benefit to the downstream Rock Creek, Cresta, and Poe reaches." (FERC EIS at 3-140.)

It is reckless and illegal for the State Board to decide to significantly impair and degrade coldwater, recreational, and other beneficial uses at Lake Almanor. To do so would violate the state and federal Clean Water Acts, state and federal anti-degradation policies, the public trust doctrine, CEQA, and numerous other state policies and laws. The County urges the State Board to heed its own statements in the EIR that: "In instances where both warm and cold water beneficial use designations occur within a single water body, such as Lake Almanor, the coldwater uses usually are the most limiting, and water quality objectives to protect coldwater habitat receive special consideration." (EIR at 6.5-3.) If the State Board selects Alternatives 1 or 2, or the "staff alternative," it will not be affording due, let alone special, consideration to Lake Almanor's coldwater habitat and its beneficial uses.

The EIR also states: "The State Water Board must also ensure that UNFFR Project operations, including any water quality measures designed to benefit the North Fork Feather River, will not unreasonably affect water quality in Lake Almanor." (EIR at 1-2.) If the State Board selects Alternative 1 or 2, or the staff alternative, the EIR demonstrates that it will be unreasonably affecting water quality and beneficial uses in Lake Almanor and Butt Valley Reservoir.

In sum, the State Board should not, cannot, and must not sacrifice and degrade the beneficial uses and recreational, biological, and aesthetic values of Lake Almanor to chase uncertain and speculative benefits from potentially slightly cooler waters downstream. There are alternative ways to achieve the cooling the State Board apparently desires, which this EIR does not, but should, analyze.

II. <u>The EIR Is Fundamentally Inadequate Under CEQA</u>

At the outset, the County wishes to make clear that it believes the flaws and deficiencies in the EIR are so numerous and substantial that they cumulatively render the EIR deficient as an informational document under CEQA. The EIR omits many analyses and discussions required by CEQA, is far too cursory in the discussions and analyses it does provide, uses inconsistent, old, or irrelevant data, and presents information in a confusing and obscure manner. In light of the magnitude and complexity of the project, the State Water Board's apparent attempt to influence water temperatures on over 40 miles of the North Fork Feather River, the huge economic costs being proposed in the alternatives (tens of millions of dollars), and the long-term consequences (40-50 years) of the State Board's certification decision, a much more thorough and substantiated environmental review is required by CEQA. Before making any final decision, the Board must make significant revisions to the EIR and recirculate it for additional public review and comment.

III. <u>The EIR's Project Description Is Inadequate</u>

An EIR must contain a "project description." (See e.g., CEQA Guidelines, Cal. Code Regs. Title 14 § 1500 et seq. ("Guidelines"), §§ 15124, 15120.) CEQA defines the "project" as "the whole of an action, which has a potential for resulting in either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment," and includes an "activity involving the issuance to a person of a lease, permit, license, certificate, or other entitlement for use by one or more public agencies." (Guidelines, §15378(a).)

The EIR indicates that the proposed project is to operate the UNFFR Project: (1) as described in PG&E's application to FERC, (2) as agreed to in the 2004 Project 2105 Relicensing Settlement Agreement, and (3) with the additional obligations imposed by Section 18 conditions, Section 4(e) conditions, and the FERC Staff Alternative. (EIR at 4-4.) The EIR then lists dozens of activities and elements that are part of the proposed project. (See e.g., EIR at 3-9 – 3-14; 3-16 – 3-18.) The County understands that many of these actions were developed through the relicensing process and in negotiations with stakeholders and federal or state regulatory agencies. As such, the County recognizes that many of these measures are important and the County hopes they will ultimately provide their intended benefits. Nevertheless, it is clear from the EIR's discussion of many of these activities that their implementation has the potential to significantly impact the physical environment. As such, and given that CEQA requires disclosure and consideration of the impacts of the "whole of the action," the short-term impacts of construction / implementation, and any long-term impacts must be evaluated. Other than providing a cursory list of these activities as part of the project, the EIR provides no meaningful description or details about them. This is insufficient under CEQA.

It is crucial to know the number, location, timing, duration, and scope of the all implementation actions that will be taken as part of the proposed project to assess their potential for causing significant environmental impacts. Without such details, it is impossible for the EIR and the public to adequately evaluate whether these elements will cause impacts (short- or long-term), and if so, the scope and magnitude of those impacts. Accordingly, the EIR's project description should be expanded to fully describe all these elements, or include a discussion of what further environmental analyses under CEQA the State Board intends to perform prior to their implementation, or explain why this information is not required to conduct an adequate environmental impact analysis of the whole of the project under CEQA.

The project elements that should be described include:

- PG&E application PM&E measure 12 (pulse flows Seneca and Belden reaches): Describe this pulse flow's size, timing, duration, expected frequency of occurrence, etc.

- PG&E application PM&E measure 18 (pulse flows Butt Creek): Describe this pulse flow's size, timing, duration, expected frequency of occurrence, etc.

- PG&E application PM&E measure 25 (removal of Gasner Bar fish barrier): Describe physical dimensions of existing fish barrier; describe removal process and its schedule and duration, etc.
- PG&E application PM&E measure 29 (implement recreation resource management plan): Describe actions that will be taken to implement management plan and their scope, location, timing, etc.
- PG&E application PM&E measure 31 (provide $5 million to fund USFS recreation improvements): Describe types of improvements and locations likely to be affected.
- PG&E application PM&E measure 32 (PG&E to assume operational and heavy maintenance of USFS facilities): Describe current state of facilities and current operational and heavy maintenance regime (i.e., necessary for baseline); describe proposed PG&E actions and implementation schedules.
- PG&E application PM&E measure 34 (reimburse CDFW for annual trout stocking in Belden reach): Describe timing, number and size of fish that will be stocked, method of planting, etc.
- PG&E application PM&E measure 51 (implement aesthetic improvement measures): Describe these measures, where will they be implemented, and their duration and timing, etc.
- PG&E application PM&E measure 52 (implement shoreline management plan): What are the elements of this plan, what actions will be taken, what times of year, duration, etc.
- FERC Staff alternative measure 10 (700 cfs pulse flow in Seneca and Belden reaches): Describe this pulse flow's size, timing, duration, expected frequency of occurrence, etc.
- FERC Staff alternative measure 15 (woody debris management plan): Describe actions, schedule, location, duration, etc.
- FERC Staff alternative measure 17 (implement vegetation and invasive weed management plan): Describe actions, schedule, location, duration, whether herbicides will be applied, etc.
- FERC Staff alternative measure 23 (implement measures in programmatic agreement re: historic properties): Describe actions, schedule, location, duration, etc.

IV. The EIR Fails To Include A Clear, Express Statement Of The State Board's Objectives

An EIR must contain a "statement of the objectives sought by the proposed project." (Guidelines, § 15124(b).) The statement of objectives is intended to "help the lead agency develop a reasonable range of alternatives to evaluate in the EIR and will aid the decision makers in preparing findings or a statement of overriding considerations, if necessary." (*Id.*)

The only objectives identified in the EIR are PG&E's objectives for the UNFFR Project, which are to:

- continue generating electricity for the term of the new license to produce electric power from a renewable sources for its customers.
- continue providing power to help meet both short- and long-term needs for power and ancillary services in PG&E's service area and within the California-Mexico Power Area.
- implement measures to conserve energy, mitigate damage to fish and wildlife (including related spawning grounds and habitat), provide recreational opportunities, and preserve other aspects of environmental quality."[1] (EIR at 3-1.)

CEQA requires that the lead agency provide its objectives, not those of the project applicant. It is apparent that the State Board has objectives that are not expressly identified as such in the EIR, which is a violation of CEQA. While the County does not know the State Board's specific objectives, a fair reading of the EIR reveals an effort to restore or enhance existing conditions in the lower North Fork Feather River regardless of whether or to what extent the proposed project has affected those conditions. The State Board's failure to expressly identify its objectives from the outset of the EIR process has had a ripple effect that also renders other parts of the EIR (e.g. alternatives development) a charade and precludes meaningful public disclosure and participation.

---

[1] This third objective is vague as to what the term "damage" refers to. It is further improper, redundant, and confusing because mitigation is a term of art under CEQA and consists of actions required by CEQA to lessen or avoid significant impacts of the proposed project. Hence, it is confusing and improper to state from the outset that an objective of the project is to provide mitigation before the EIR review process has even identified any significant impacts that may require mitigation. Please explain what "damage" is sought to be "mitigated," and where the analysis of this is located.

V. <u>The EIR's Environmental Baseline Does Not Accurately Represent The Existing Environmental Setting / Conditions</u>

The EIR's analyses use old and shifting baselines. Consequently, this renders the EIR's various analyses deficient because they fail to accurately and consistently assess potential environmental impacts. These methodological errors also obscure from and confuse the public regarding the potential for actual environmental impacts.

A. <u>The Year 2005 Is An Inappropriate And Unrepresentative Baseline</u>

The EIR states "[t]he baseline conditions for this EIR are the physical environmental conditions at the time the Notice of Preparation (NOP) of this EIR was published on August 30, 2005." (EIR at 1-6; See) So the baseline is already 10 years old. The County acknowledges that the CEQA Guidelines state that the baseline may often be set to when the lead agency files its NOP, but the CEQA Guidelines also presume that a lead agency will expeditiously complete the EIR process in far less than 10 years. (See e.g. Pub. Re. Code § 2110.2, CEQA Guidelines § 15108).

Use of 2005 as the baseline for this EIR is inappropriate. It fails to provide a realistic environmental setting from which to judge the environmental impacts of the proposed project and alternatives. For instance, since 2005, the State has experienced the worst drought in its recorded history and precipitation, snowpack, and river levels have been at or near all-time lows. The EIR's use of 2005 as the baseline totally fails to capture this recent data. The attached reports by Doctors Johnston and Rich, which the County commissioned, further discuss recent conditions and emerging trends in water quality and biological parameters at Lake Almanor and the lower North Fork and how they differ from past conditions. (<u>See Attachments 1 and 2</u>.) Data and reports prepared by PG&E staff and other materials document these recent trends. (<u>See Attachment 3</u>.) Similarly, there is no disputing that the occurrence of plants and animals, the density of traffic, and the numbers of visitors and recreational users of Lake Almanor can and likely have changed from 2005 to 2015 (e.g., increasing population, etc.)

CEQA is not concerned with hypothetical impacts that might have occurred upon project implementation years ago; CEQA is concerned about real-world impacts today. The EIR provides no rationale explaining how its use of the 2005 baseline is appropriate or reasonable to assess the impacts of proposed alternatives that will not even be fully implemented until 2016 or likely later. It is contrary to the intent and purpose of CEQA and an unreasonable interpretation of CEQA and the CEQA Guidelines to suggest that a lead agency may file an NOP, and then delay finalizing its EIR for a decade or more, and nevertheless cling to the original NOP date as the baseline whenever it gets around to completing the document. Such gamesmanship obscures meaningful analysis and carries substantial risk of failing to properly evaluate and disclose the actual impacts a project or alternative will have when it is implemented.

B. <u>The EIR Must Use A Consistent Baseline</u>

The EIR's inappropriate and unsupported use of an outdated 2005 baseline is further compounded by the fact that the EIR does not even stick to its chosen baseline of 2005. Instead, the EIR inconsistently uses other and multiple dates as the baseline for many analyses, a few of which (but by no means all) are highlighted below.

1. The Baseline Geology, Geomorphology and Soils Includes 2007 Data

For example, the Environmental Setting for Geology, Geomorphology, and Soils (EIR Section 6.3.1), includes physical characteristics existing after 2005. In that section, the EIR states: "Stetson Engineers inspected the Lake Almanor shoreline by boat on June 28, 2007 (Stetson Engineers 2010). The purpose of the field inspection was to evaluate shoreline characteristics related to erosion activity from fluctuating lake levels. The field inspection focused on areas that demonstrated significant erosion, as documented during previous field inspections. Locations of active shoreline erosion were consistent with those previously documented by PG&E. Based on the 2007 inspection, shoreline erosion has not changed, which is likely because of PG&E's consistent operations." (EIR at 6.3-10.) The inclusion of 2007 survey information in the environmental setting for this resource is inconsistent with the EIR's stated baseline of 2005.

2. The Baseline For Water Quality Includes 2000, 2009, 2010, 2011 Data (Among Others)

Another similar example appears in the environmental setting for water quality (Section 6.5.1). There, the EIR again presents conditions existing after 2005 as representing the baseline, stating: "Figures 6.5-1a and 6.5-1b illustrate the seasonal pattern of thermal stratification that occurred in Lake Almanor in the general vicinity of Canyon dam from 2000 through 2010 under a variety of hydrologic conditions." (EIR at 6.5-5.) Thus, the EIR uses many years both before and after the year 2005 to describe baseline thermal regimes at Lake Almanor. For baseline dissolved oxygen concentrations, the EIR states: "Figures 6.5-2a and 6.5-2b illustrate the seasonal depth patterns of DO concentrations near Canyon dam during the summer for a variety of water year types (2000- above normal; 2009-dry; 2010 - below normal; and 2011 - wet)." (EIR at 6.5-6.) (See also, Draft EIR, at 6.5-4 [stating that in 2006, "PG&E conducted a series of special tests to provide data for the analysis presented in this EIR"]; *ibid.* [referring to recent water quality monitoring by Plumas County Flood Control and Water Conservation District (Johnston and McMurtry 2010)];) Again, none of the years selected by the EIR for the DO baseline are 2005. Similar inconsistencies and variable baselines occur throughout the EIR and its appendices.

In sum, even if 2005 were an appropriate baseline (which it is <u>not</u>), the EIR nowhere explains its deviation from its chosen baseline of 2005 or why so many other years are included in its various environmental setting discussions (see also wildlife analyses relying on 2002 surveys as baseline for distribution and presence/absence determinations), or why there is so much variability and inconsistency between the baselines chosen for different analyses. Furthermore, the use of that post-date 2005 essentially concedes and confirms that more recent information than 2005 is relevant and necessary to accurately describe the environmental setting and to use as the baseline to conduct appropriate impact assessments under CEQA in this EIR. The State Board needs to update its baseline to reflect more recent or current conditions and revise the entire EIR so that all its impact analyses use one, consistent baseline.

VI. The EIR Fails To Fully and Accurately Evaluate and Disclose the Impacts of the Proposed Project

The EIR does not provide a complete or accurate assessment of the impacts of the proposed project.

1. The EIR Does Not Provide A Clear Analysis Of The Impacts of The Proposed Project

The EIR includes Tables 3-1 and Table 3-2 (EIR at 3-15), which document increased flows from Canyon Dam and Belden Dam as part of the proposed project, but there is no analysis of the effects of these flows on temperature, recreation, biological resources, sediment transport, or other resource categories as compared to the baseline.[2] If there is such an analysis it is confusing. At the very least, please provide a table listing the Canyon dam releases and Seneca reach flows for each month and year type for the baseline, proposed project, and Alternatives 1 and 2.

2. Please Confirm That The EIR's Analyses Demonstrate That The Proposed Project Will Actually Reduce Baseline Water Temperatures In The North Fork Feather River

In general, the County believes that the increased flows that are part of the proposed project will beneficially impact temperatures (i.e., reduce them) in the lower reaches. However, this analysis does not appear to be presented in the EIR, or if it is, it is not easily identifiable as such. Again a table providing water temperature in reaches of the river for the baseline, proposed project, and alternatives would be very helpful in disclosing this information to the public. In light of the fact that this is one of the biggest issues in the EIR, to provide full

---

[2] On the issue of flows in the Seneca reach, the County bases its comments in this letter on a baseline flow of 35 cfs for all months of the year, which the County understands to be the EIR's baseline for this factor. If this is incorrect, please explain what the EIR used as baseline flows in the Seneca reach for each month and different water year type and the inconsistency with the EIR's modeling analyses appendix and other statements in the EIR identifying 35 cfs as the baseline.

disclosure of impacts, and to allow a meaningful comparison of the various alternatives presented in the EIR, please expressly confirm that the State Board's analyses for this EIR determined that the proposed project will reduce baseline water temperatures in the lower North Fork Feather River during the summer months.[3]

3. The EIR Fails To Analyze The Impact Of Components Of The Project

The EIR also fails to adequately evaluate other measures included in the proposed project that will likely have potential impacts when compared to baseline conditions, including:

- pulse flow of 700 cfs in the Seneca reach and in the Belden reach in March of dry water years
- implementation of a woody debris management plan
- develop and implement vegetation and invasive weed management plan
- implement historic preservation measures as described in the Programmatic Agreement

(EIR at 3-16 - 3-18) The impacts of many other elements of the proposed project, which the County's comments on the project description identified, are also omitted from analysis and must be included.

4. The EIR Obscures And Precludes A Meaningful Comparison Between the Proposed Project And Alternatives

By ignoring or obscuring the impacts of the proposed project on the environment – many of which the County believes are beneficial but which is a conclusion that should be tested and confirmed by the EIR – the EIR misleads the public and decision makers regarding the efficacy and value of the proposed project and deprives them of the information needed to accurately and objectively balance and compare the merits and costs of each alternative. The EIR must first adequately describe the proposed project and then it must analyze the environmental effects of all parts of the proposed project.

VII. The EIR Fails To Evaluate A Reasonable Range Of Alternatives

An EIR must "describe a range of reasonable alternatives to the project, or to the location of the project, which would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project, and evaluate the

[3] Figures 2-10(a&b), 2-11(a&b), 2-12(a&b), and 2-13(a&b) in the Level 3 Report appear to reveal that the proposed project (i.e., "present day" model scenario) will actually reduce downstream water temperatures as compared to the baseline scenario.

comparative merits of the alternatives." (Guidelines, § 15126.6(a).) "The range of feasible alternatives shall be selected and discussed in a manner to foster meaningful public participation and informed decision making." (Guidelines, § 15126.6(f).)

A. The State Board's Failure To Identify Its Objectives Rendered The EIR's Alternative Development And Screening Process Defective From The Start

As the California Supreme Court has explained:

> The process of selecting alternatives to be included in the EIR process begins with the establishment of project objectives by the lead agency. A clearly written statement of objectives will help the lead agency develop a reasonable range of alternatives to evaluate in the EIR…. (*In re Bay Delta Programmatic Environmental Impact Report* (2008) 43 Cal.4th 1143.

The EIR's failure to include a clear statement of the State Board's objectives (see County's separate comments on this issue), renders the EIR's alternatives analysis fatally defective from the outset. The EIR contains no discussion of the State Board's objectives and how the development of alternatives related to those objectives.

B. Alternatives 1 and 2 Are Not Proper CEQA Alternatives

1. Alternatives 1 And 2

Alternatives 1 and 2 bear no resemblance to actual CEQA alternatives and their inclusion in the EIR is improper. Under CEQA, alternatives to the proposed project are those that would avoid or substantially lessen any of the significant effects of the proposed project while at the same time meeting most of the lead agency's objectives. (CEQA Guidelines § 15126.6.) The EIR appears to claim this is the case by stating the "purpose of the proposed modifications [in Alternatives 1 and 2] is to address the potential impacts of the 2004 Settlement Agreement flows." (EIR at ES-5.) However, this statement is misleading, wholly unsupported, and contradicted by the EIR's own modeling of the effects of the proposed project on baseline water temperatures under baseline flow conditions (i.e., 35 cfs Seneca releases in every month). What impacts of 2004 Settlement Agreement flows are being addressed? Where are these impacts analyzed and disclosed? The County's review uncovered that the existing analysis in the EIR demonstrates that the proposed project's increased cold water flows down the Seneca reach would slightly reduce baseline water temperatures in reaches of the North Fork. Thus, the proposed project will not have a significant effect on river temperatures, and the EIR does not identify any significant effects of the proposed project on temperatures in the lower North Fork. Thus Alternatives 1 and 2 are improper under CEQA because CEQA alternatives are not supposed to address non-existent or beneficial impacts of the proposed project.

2. Alternatives 1 And 2 Are Actually State Board Project Proposals

By including Alternatives 1 and 2 in the EIR and claiming they were developed to address impacts caused by the proposed project, the SWRCB has made the same mistake as the appellate court in the *In Re Bay-Delta* case by "failing to sufficiently distinguish between preexisting environmental problems" in the lower North Fork and "adverse environmental effects of the proposed [project]." (*In Re Bay-Delta* (2008) 43 Cal. 4th 1143, 1167.) To correct that error, the Supreme Court mandated:

> Under CEQA, the range of reasonable alternatives that an EIR must study in detail is defined in relation to the adverse environmental impacts of the proposed project. An EIR must include a description of feasible project alternatives that would substantially lessen the project's significant environmental effects. [cites] The project's environmental effects, in turn, are determined by comparison with the existing baseline physical conditions. [cites]. (*In Re Bay-Delta* at 1167.)

The EIR fails to perform this analysis and so there is no substantial evidence to justify Alternatives 1 and 2 and they are improper under CEQA. The EIR's claim that "Alternative 1 and 2 were developed to address significant impacts identified during the scoping process" further demonstrates that the State Board's entire alternatives development and selection process was fatally flawed and not in accord with CEQA. Determinations regarding a proposed project's significant impacts are not made during the scoping process, but through the EIR process after careful analysis. Here, the EIR demonstrates the proposed project will not have any significant impacts on river temperatures that would require development of CEQA alternatives to address the issue. (EIR at ES-2.)

Instead of CEQA alternatives, Alternatives 1 and 2 are, in fact, the State Board's proposed projects to satisfy a different set of objectives that are not expressly identified anywhere in the EIR – namely, ways to reduce lower North Fork water temperatures regardless of whether the proposed project causes any significant impacts and regardless of proximate cause or any analysis of the relative contribution of the multiple factors affecting (and likely increasing) water temperatures 20-30 miles downstream of Canyon dam. In fact, the proposed alternatives violate CEQA because they actually would cause more significant environmental effects than the proposed project itself!

C. <u>The Staff Alternative Is Not Properly Analyzed And Cannot Be Chosen</u>

1. The Staff Alternative Is Not A Proper CEQA Alternative

The County objects to the staff alternative, and the notion that the State Board would subject the County and its residents to living under the cloud of thermal curtains for years to come. The County, the community, and stakeholders have invested too much time already in opposing these unreasonable measures. Also, beyond this basic opposition, the EIR provides no basis for the State Board to adopt the so-called staff alternative because it is not evaluated at a commensurate level with the other alternatives. The EIR does not explain how the staff alternative was developed, and it is clear that it was developed outside the EIR's alternatives development process and for a set of objectives that are undisclosed.

2. The Description Of The Procedure For Triggering Future Thermal Curtain Installation Is Fatally Vague And Any Such Future Decision Must Be Subject to Separate CEQA Review

Furthermore, the EIR is too vague in its description of the staff alternative. The EIR must describe the process for determining whether and if so when thermal curtains would be required in the future. That process must be clear and precise and include objective measures that would trigger thermal curtain installation. Without such details and definitive triggers, any future thermal curtain installation would be an entirely new project subject to new CEQA review when the State Board proposes it. Any action to install thermal curtains in the future must be subject to a new State Board decision and a separate project-specific CEQA review because the analysis in the present EIR will be outdated and irrelevant. Please confirm that any future requirement to install thermal curtains would be subject to project-level CEQA review and that this review would consider extant conditions and circumstances at that time. Alternatively, if this is not the case please explain and support the State Board's apparent position that this EIR adequately evaluates the impacts of future implementation of the thermal curtains.

Another reason the concept of future implementation of thermal curtains is an improper alternative in the current EIR is that the current EIR has not, and cannot, support a conclusion that thermal curtains will be the only viable, feasible alternative measure to cool lower river water temperatures in the future (possibly several decades from now). The County and others have already provided numerous alternatives to the thermal curtains that we believe are viable today to help cool lower river water temperatures. Those and other measures may become feasible in the future with advances in technology, changed cost of implementation and other economic circumstances, increases in our understanding of the system and additional data, climate change and social and biological objectives. Thus, if the State Board were ever to consider thermal curtains 20 years from now, for instance, it would have to consider these other alternatives. The current State Board cannot vote to adopt the staff alternative and then delegate to staff the determination of whether to impose thermal curtains in the distant future.

In sum, the staff alternative's attempt to preserve for the future a decision to require installation of thermal curtains is an illegal Trojan Horse. Given the significant impacts on beneficial uses at Lake Almanor that thermal curtains would have if implemented today, it is unimaginable that they will be justified at any time in the future, when climate change and other factors will continue to exacerbate the already delicate, precarious coldwater habitat situation at

Lake Almanor during the summer/fall. Thermal curtains should be eliminated from consideration entirely.

D. The EIR Improperly Excludes Analysis Of Other Feasible Alternatives

The EIR admits the existence of other feasible alternatives that were excluded from the EIR without explanation: "Although many measures were determined to be potentially feasible, three of the measures were carried forward for analysis in the EIR. Two alternatives including these measures were created for the CEQA analysis." (EIR at ES-4 - ES-5.)[4] The EIR reveals that the costs of the existing Alternatives 1 and 2 (in 2009 dollars) are: (1) Prattville thermal curtain = $14,847,000; (2) Modify Canyon Dam outlet = $10,702,000; (3) Caribou thermal curtain = $8,720,000 (See Level 3 Report at ES-12.) Given these very high monetary costs, and the significant environmental and socio-economic costs of Alternatives 1 and 2 (e.g., fish kills, unavoidable significant aesthetic impacts, unavoidable significant cultural resource impacts, loss of hydropower generation, etc.) it is inconceivable that the State Board would ignore so many other alternative measures to cool downstream temperatures or find that these other measures were somehow infeasible as compared to Alternatives 1 or 2.

1. The EIR Admits It Excluded Feasible Alternatives

Furthermore, the EIR admits it excluded feasible alternative measures from proper consideration. It explains that 16 discrete alternatives were advanced from Level 2 screening to Level 3, and that these alternatives" represented the set of potentially effective and feasible project alternatives." (EIR at 4-2.) The EIR states that these alternatives "included flow-related operational measures for the downstream Rock Creek, Cresta, and Poe reaches and physical modification for the Poe reach.' (*Id.*) It then explains that it categorized alternatives as UNFFR Project-only if all measures were entirely within the UNFFR Project boundary and subject to FERC jurisdiction, and further explains that "[n]o detailed screening of alternatives was conducted for reaches outside (downstream) of the UNFFR Project boundary in the Level 3 analysis, and these measures were not carried forward in this EIR." (EIR at 4-2.)

Elsewhere, the EIR again confirms that it excluded otherwise feasible alternative measures from the EIR: "other alternatives [that made it to Level 3] are not evaluated separately in this EIR because of consideration to the controllable factors by PG&E for the UNFFR Project." (EIR at 4-4.) The Level 3 Report (EIR Appendix) also states: "To carry out the two discretionary actions [401 certification and CEQA compliance] with consideration to the controllable factors under PG&E's control, which may achieve compliance with Basin Plan objectives, this Level 3 report analyzes the effects of the UNFFR Project-only alternatives....No

[4] In making these comments the County does not waive its objection that the entire alternatives analysis process in the EIR was fatally flawed because it did not focus on avoiding or lessening significant impacts of the proposed project.

detailed screening of water temperature reduction alternatives was conducted in reaches outside (downstream) of the UNFFR boundary in this Level 3 analysis." (Level 3 Report at ES-3.)

2. CEQA Requires Consideration Of Feasible Alternatives And Measures At The Lower Hydroelectric Projects

The EIR's rationale for excluding otherwise feasible alternatives is confusing and has no basis in CEQA, other laws, or logic. The EIR admits that the UNFFR Project operations are integrated with operations of the Rock Creek-Cresta and Poe Projects. Furthermore, the State Board has jurisdiction over PG&E through this certification process for the UNFFR Project, and it also has jurisdiction over PG&E's operations of the UNFFR Project and all the other PG&E-operated hydroelectric projects on the North Fork Feather River by way of its regulatory authority over PG&E's water rights for water used in those projects. Thus, the State Board clearly has the authority to impose operating conditions on any of the lower river hydropower projects if it believes that this is necessary to achieve its apparent objective of avoiding temperature exceedances in the lower North Fork. In sum, the EIR's stated rationale for excluding the many other measures that are admittedly feasible on the basis that these are not controllable factors by PG&E or the State Board is unsupported and wrong. An alternative with some of the other downstream measures that the Level 2 report found feasible should be developed, analyzed, and included in the EIR.

Finally, the State Board's exclusion of any alternatives that involve reoperation of facilities or measures outside the UNFFR Project boundaries (as narrowly and improperly defined by the State Board) is inconsistent with its statement that "a wide range of potentially feasible alternatives for seasonal cooling of water temperatures in the North Fork Feather River was considered…." (EIR at 4-1.) In reality, the application of the State Board's illegal "controllable factors" exclusion rendered many other factors beyond consideration even though they might achieve the cooling effect the State Board is seeking

3. The EIR Should Fully Analyze A 250 cfs Canyon Dam Release Without Thermal Curtain Alternative

The EIR states: "while not separately evaluated as an alternative, increased releases from Canyon dam of up to 250 cfs between June 15 and September 15 could be implemented to reduce temperatures in the North Fork Feather River. The impacts of Canyon dam releases independent of thermal curtains would be a subset of those identified for Alternative 1 (i.e., only impacts related to modification of the Canyon dam outlet and increased flows, not impacts related to construction and operation of the thermal curtains." (EIR at ES-6.) This alternative should be separately and fully evaluated as a stand-alone alternative because it would avoid the significant aesthetic impacts of thermal curtains and reduce coldwater impacts to Lake Almanor.

4. Riparian Restoration And Shading Of The East Branch And Other River Stretches And Tributaries

The County continues to support consideration of riparian restoration and riverine habitat improvement as a viable measure to achieve permanent and robust benefits for the watershed, including water temperature reductions and increased summer flows in the lower North Fork. The County incorporates its previous comments on this issue provided during the scoping process. Figure 2-4 in the EIR's Appendix E (Level 3 report) demonstrates the significant contribution to temperature exceedances caused by the East Branch North Fork as a consistent spike of over 1 C is seen in June and July baseline numbers and a more modest increase in August 50% exceedance temperatures. The September data also show that the East Branch can be an effective source of cooling as there is a decrease in temperatures at that point.

The EIR provides inadequate justification for excluding this alternative. First, the EIR states this alternative would not reduce water temperatures in the Seneca reach because the East Branch is downstream, however, temperatures in the Seneca reach will be reduced by the proposed project's increased Canyon Dam releases and are, and will be, lower than 20 C. The EIR does not identify lowering the water temperature in the Seneca reach as an objective of the project. Second, the EIR states that "only a minor improvement in water quality could be expected in the North Fork Feather River downstream of the East Branch because the East Branch contributes only a small percentage of flow to the river during the summer months." (EIR at 4-4.)

Furthermore, the EIR fails to consider restoration and shading measures on other reaches of the North Fork, even though project documents state that "existing shading of the Poe Reach is approximately 22% ....Water temperature modeling indicates that increasing total shading of the Poe Reach to 50% would reduce warming by 0.8 C." And "[e]xisting shading of the Cresta Reach is approximately 30%...Water temperature modeling indicates that the benefit of increasing Cresta Reach shading from existing 30% to 60% would be a reduction in warming by about 0.5 C."

Even incremental benefits to water temperature or in segments of the downstream reaches appear to serve the State Board's unstated, but apparent, CEQA objective to improve downstream temperatures and fish habitat, and this could be a viable method to be used in conjunction with other measures to craft an alternative that lessens or does not cause significant impacts to Lake Almanor itself as every drop of cold water that remains in Lake Almanor decreases the loss of the coldwater pool and habitat there from Alternatives 1 and 2. The EIR fails to take a hard look at riparian restoration measures and is close-minded regarding other alternatives that include a combination of measures to achieve the State Board's apparent objective.

5. The EIR Must Consider An Alternative That Includes Adaptive Management Of Canyon Dam Releases In Combination With Other Operational Measures At Other PG&E Facilities On The North Fork To Preserve Cold Water In Lake Almanor

There are many other ways to achieve cooling in the lower reaches in ways that are less damaging to Lake Almanor's coldwater habitat and fishery that the EIR has improperly neglected to explore. Because taking water from Lake Almanor has significant effects, the EIR must perform and disclose feasible alternatives that would lessen or avoid this impact, as well as the significant, allegedly unavoidable aesthetic impact of thermal curtain installation. One promising alternative that must be analyzed is a combination of operational measures that would be managed and implemented to cool river temperatures in real-time. Attachment 13 to this letter provides is an April 30, 2012 submittal by PG&E to FERC that provides an official, adopted, and existing procedure for implementing operational measures at various PG&E facilities on the North Fork to achieve cooler riverine water temperatures when exceedances of 20 C are threatened or occur. Attachment 13's interim control measures include five (5) temperature control (i.e., water cooling) measures whose effects (as stated in the attachment) are summarized below:

- Maximize the release of Rock Creek and Cresta reservoirs to the low-level outlet located approximately 30 feet below the radial gates, which could potentially provide deeper, cooler water to the Cresta and Rock Creek reaches.

- Operate Caribou 1 Powerhouse over Caribou 2. Caribou 1 has the potential to access a limited amount of colder water from the deeper portions of Butt Valley Reservoir. In order to preserve the finite amount of cold water in Butt Valley Reservoir, PG&E will maintain that reservoir at maximum pool and minimize the operation of Caribou 1 until July 15. This measure along will provide 5 or more days of colder water withdrawal.

- Operate Bucks Creek Powerhouse in a manner that will help reduce daily average water temperatures.

- Increase minimum instream flows from Rock Creek and Cresta dams to reduce ambient warming during the day.

Attachment 13 also demonstrates that these measures were approved by various stakeholders and agencies. This demonstrates that these measures are available and in combination can address water temperatures in the lower river without impacting Lake Almanor. The EIR should evaluate these measures (and any others including riparian shading) as a CEQA alternative because every drop of cold water that such an alternative allows to remain in Lake Almanor decreases the loss of the coldwater pool and habitat there, which lessens or avoids the significant impacts Alternatives 1 and 2 would cause. In failing to craft such an alternative, the EIR violates CEQA.

VIII. The County Agrees With The State Board's Elimination Of 600 cfs Canyon Dam Release As An Infeasible And Imprudent Alternative

The County agrees with the State Board's determination not to include in the EIR alternatives that would require 600 cfs releases from Canyon Dam, or any other alternative that would require releases over 250 cfs because such alternatives are infeasible, unreasonable, and unjustifiable.

IX. If The State Board Wishes To Address Existing Warm Temperatures In The Lower North Fork, It Should Engage In A Focused CEQA Or Water Rights Process And Analysis To Comprehensively Address That Issue

The EIR's development of alternatives was not in accord with CEQA and was not in response to avoiding or lessening any significant effects of the project, but instead appears to be an outcropping of the State Board's desire to reduce water temperatures in the lower Feather River regardless of the proportional causal effect of the proposed project as opposed to a whole suite of other factors including the lower-river hydroelectric projects, climate change, land use and other anthropogenic changes, as well as natural physical and biological processes (e.g., potential increased evapotranspiration of vegetation in the watershed causing reduced and therefore warmer flows). This is evident in the EIR's statement that; "The State Board has evaluated a range of alternatives to ensure that the UNFFR Project will comply with the Basin Plan." (EIR at 4-1.)

The State Board should conduct a thorough, not piecemeal, CEQA or other review of ways to achieve basin plan compliance.

X. The Description Of The "No Project" Alternative Is Insufficient

The EIR must evaluate a "no project" alternative. (Guidelines, § 15126.6(e)(1).) "The purpose of describing and analyzing a no project alternative is to allow decision makers to compare the impacts of approving the proposed project with the impacts of not approving the proposed project." (*Id.*) The "no project" analysis must explain "what would be reasonably expected to occur in the foreseeable future if the project were not approved . . . ." (Guidelines, § 15126.6(e)(2).) "[W]here failure to proceed with the project will not result in preservation of existing environmental conditions, the analysis should identify the practical result of the project's non-approval and not create and analyze a set of artificial assumptions that would be required to preserve the existing physical environment." (*Id.*) The EIR's discussion of the no project alternative and its potential impacts fails to conform to CEQA's requirements and is inadequate for CEQA's purposes. (See i.e., EIR at 8-3 - 8-4.) The discussion is far too general and cursory for informed disclosure and decision making.

A. Lost Power Production

The EIR states that the no project alternative would reduce power generation by about 1,172 GWh/YR and that power production in the downstream Rock Creek-Cresta and Poe projects would be "substantially reduced," but the EIR fails to quantify the power production that would be lost from the lower projects and fails to elaborate on the implications of this loss of power production, especially in the summer months. How many homes could this energy power? This omission is unsupported and unreasonable, especially in light of the EIR's statements that "[t]he UNFFR Project is a resource that is important to the operation of PG&E's Feather River hydroelectric system as a whole; it contributes to PG&E's resource diversity and plays a part in meeting the electrical generation capacity requirements of both PG&E and the state of California." (EIR at 3-4.)

B. Lost Recreation And Visitors

Elsewhere, the EIR states that "loss of opportunities for flat-water recreation on Lake Almanor and Butt Valley reservoir could affect nearby communities as well as larger Plumas County due to a reduction in visitation to the area," but it again fails to quantify this impact or elaborate on the implications of this conclusion. (EIR at 8-4.) What dates were used to make this determination? How many fewer visitors will visit on average? (See Section XII.)

C. River Flows Without UNFFR Project

The EIR also includes no analysis and discussion of what the water flows and temperatures would be in the North Fork Feather River if the proposed UNFFR Project were not granted a new license and its operations ceased. What would North Fork water temperature and flows be under the No Project?

D. Separate Determinations Of Significance Required

Finally, the EIR also improperly omits to make significance determinations regarding the impacts of the no project alternative on the various resource categories the EIR addresses. This deprives the public and decision makers of the ability to evaluate the merits of the no project and other alternatives. (See e.g., Guidelines § 15126.6(e)(1) ["The Specific alternative of 'no project' shall also be evaluated along with its impact."].) Please provide a significance determination for each resource category.

XI. The EIR's Analyses Of Project Impacts And Conclusions Regarding The Effectiveness of Mitigation Are Deficient

"The determination of whether a project may have a significant effect on the environment calls for careful judgment on the part of the public agency involved, based to the extent possible on scientific and factual data." (CEQA Guidelines, § 15064(b).) Here, the EIR's failure to perform particular analyses, reliance on conclusory analyses, and reliance on inconsistent, unsupported, and illogical statements demonstrate that the State Board failed to exercise the required careful judgment demanded by CEQA when assessing and disclosing potential environmental impacts. "An omission in an EIR's significant impacts analysis is deemed prejudicial if it deprived the public and decision makers of substantial relevant information about the project's likely adverse impacts." (*Neighbors for Smart Rail v. Exposition Metro Line Const. Auth.* (2013) 57 Cal. 4th 439, 463.) The errors in the EIR's impact analyses described below are prejudicial. For similar reasons and as described below, errors in the development and discussion of the EIR's mitigation measures also violate CEQA and are prejudicial.

A. <u>Land Uses and Mineral Resources</u>

1. Inadequate Mitigation For Loss Of Beach

The EIR discloses that Alternatives 1 and 2 would cause a significant impact to land uses. One such impact is the total loss of the Marvin Alexander Beach day use area. (EIR at 6.2-9) As mitigation, the EIR proposes creation of another day use area that it concludes will reduce this impact to a less than significant level. However, the discussion regarding the proposed mitigation measure is vague and does not support the EIR's conclusion that this impact would be reduced to a less than significant level. At the very least, to ensure the potential feasibility and effectiveness of this proposed mitigation measure, the EIR must survey whether there are any suitable alternative beach locations around Lake Almanor, and identify them. Also, the EIR must describe and quantify the level of access and amenities that will be required at any alternative beach site to ensure effective implementation and enforcement of this measure. Finally, the EIR should provide more detail regarding the process to identify any alternate beach location, and the EIR should provide a defined date to identify, implement, and complete the beach replacement effort. Also, the EIR should include a default process to definitively select an alternative beach area if the parties cannot agree on a location, a required implementation date, and require establishment of an escrow account with a set sum of money to ensure that the mitigation measure is timely implemented and enforceable.

2. Mining Impacts Inadequately Analyzed

The EIR's conclusion that the impact on mining activities in the Seneca and Belden reaches would be less than significant is unsupported and cursory. The EIR admits:

> [I]ncreased flows would raise water levels in the Seneca reach during certain periods of the year and could disrupt placer mining activities at some of the active mining locations along these reaches. Higher water levels could impair the ability of some miners to access and mine these sites along the reaches. Some miners may need to adjust their mining schedules to avoid the periods of increased releases. (EIR at 6.2-11.)

The EIR claims this is a less than significant impact because "few active mining properties would be negatively affected, the disruptions would be short term, and the mineral resource would still be available during lower flow periods." (*Id.*) However, the June through September period of proposed higher flows corresponds to the time of year when these mines are most active because the weather and other conditions are most favorable. Thus, the EIR's assumption that mining can or does occur at the same rate at other times of year (or evenly during every month of the year) is inaccurate and unsupported. For instance, Plumas County recently granted a use permit for the Seneca Mine that specifies mining must occur during April 1- October 31. (See Attachment 12.) Thus, if the 250 cfs releases obstruct access during June 15 – September 15, this could represent a significant percentage of the actual annual operation period of the mine. The EIR also fails to make a significance determination with respect to this impact for the proposed project, separate from its conclusions regarding Alternatives 1 and 2.

3. Shoreline Erosion

The EIR's conclusion that the impacts of the proposed project on shoreline erosion at Lake Almanor is significant without mitigation is unsupported. The EIR's analysis of shoreline erosion expressly states that "[t]he magnitude and patterns of erosion would not be different than those currently occurring at the lake; neither the UNFFR Project nor either alternative would modify lake operations in a way that would increase erosion. (EIR at 6.3-17.) Furthermore, the proposed mitigation of requiring implementation of an updated shoreline monitoring and management plan is vague and does not support the EIR's conclusions that the mitigation will reduce the significant impact. The County agrees that shoreline erosion at Lake Almanor must be carefully monitored and addressed. At the very least, however, the EIR needs to describe the required contents of any such erosion plan, including quantifiable performance objectives, a schedule for preparation, implementation, and monitoring protocols, provide detailed and enforceable method of budgeting and paying for these costs and the specific measures that will be employed to limit erosion.

4. Seneca Reach Flow Analysis Confusing and Inadequate

The EIR's analysis of changes in the channel morphology of the Seneca reach is inadequate , confusing, and uses an inconsistent baseline. The EIR claims a less than significant effect on the Seneca reach from the increased releases of 250 cfs from Canyon dam proposed in Alternative 1. The EIR supports this conclusion by stating that "[a]lthough flows would increase in the Seneca and Belden reaches, changes in the river morphology would be similar to the current variable conditions…." (EIR at 6.3-16.) The variable conditions the EIR claims to use as a comparison for this effect determination do not comport with the stated baseline condition for the Seneca reach, which is 35 cfs every month as required in the existing FERC license (or interim renewal). There are no variable flows in the baseline. This is yet another example of the EIR's use of confusing, inconsistent and multiple baselines.

Elsewhere, the EIR admits that "a 250 cfs release would be substantially higher that the current flow discharged from Canyon Dam...." (EIR at 6.3-16.) The EIR states that these flows "could transport sediment and woody debris along the channel and deposit these materials downstream in the Belden forebay or other reservoirs." (*Id.*) The EIR should assess whether, on account of this effect, Belden forebay will need to be dredged more frequently and the potential impacts of the activity.

The EIR's water resources analysis confirms that "[t]he Seneca reach would experience an increase in minimum flows from 35 cfs to between 60 and 150 cfs under the 2004 Settlement Agreement." (EIR at 6.4-6.) It states "[t]he short term changes could result in flooding along the canyon in areas that have not been frequently inundated...." (*Id.*) After reaching this conclusion for flows well below 250 cfs and then characterizing the increase to 250 cfs as "substantially higher" than the baseline flow, the EIR nevertheless concludes without analysis or support that ["w]ith the minimal seasonal flow changes, impacts on other resources along the North Fork Feather River, such as riparian vegetation, wildlife, soils, and river morphology, would also be minimal." (EIR at 6.4-7.) The EIR provides no basis for its conclusion that flooding new areas with "substantially higher" flows will result in only "minimal" impacts to those resources.

The EIR's analysis of the water resources impact of Alternative 1 does not adequately analyze the increased flow releases "up to 250 cfs in the Seneca reach from June 15 through September 15." (EIR at 6.4-7.) The EIR does not analyze the impact of increasing Seneca reach flows from 35 cfs in the baseline condition to 250 cfs - over a seven-fold increase. The EIR improperly relies on the analysis of the proposed project's impacts of much lower flows during this period to conclude that "effects of increased minimum flows in the Seneca reach would be similar to those outlined above for the Proposed UNFFR Project." (EIR at 6.4-7.) There is no justification for combining the effects analyses of different alternatives like this and it is confusing and misleading. The EIR concludes that the Seneca reach would experience "changes in its flow regime", but again claims without support "[w]ith the minimal seasonal flow changes, impacts on other resources along the North Fork Feather River, such as riparian vegetation, wildlife, soils, and river morphology, would also be minimal." (EIR at 6.4-8.)

B. Water Quality

As part of its review of the EIR, the County commission expert Dr. Gina Johnston to provide in-depth review of the EIR's water quality discussion, analyses, and conclusions in addition to providing general comments on the adequacy of the EIR. The final report and qualifications of Dr. Johnston are attached as Attachment 1. The County fully incorporates those comments here and requests that the State Board separately respond to the issues raised by Dr. Johnston, as well as to those provided below.

1. No Analysis Of Water Quality Without UNFFR Project

The State Board apparently developed the EIR with the premise that the proposed project must be altered. The EIR fails to explain or justify the basis for that position. The EIR states that it "focuses on potential modifications to the existing UNFFR Project that may be implemented to better protect the overall beneficial uses of the North Fork Feather River, while limiting water quality impacts to the beneficial uses of Lake Almanor." (Draft EIR, at 6.5-3.) The EIR does not provide historic data that shows what the flows and water temperatures would be without the proposed UNFFR project.

2. Alternative 1 Impact Significant In Normal Years

The EIR's conclusion that Alternative 1 will have less then significant impacts in normal water years is unsupported, fails to account for the already significantly limited coldwater habitat available under the baseline and in the future under reasonable climate change scenarios, and is inconsistent with the EIR's chosen significance thresholds. The threshold is a "substantial water quality change[] that would adversely affect beneficial uses." (EIR at 6.5-15.) The EIR's analysis for Alternative 1 states that it would reduce the volume of cold water in mid-August by 23.5 percent. (EIR at 6.5-18; EIR at 6.5-27 ["The 250 cfs release from Canyon dam [under alternative 1] would draw more water from the hypolimnion than occurs under the current 35 cfs release."].) The EIR claims that this is less than significant because of the "relatively small volume of suitable cold water habitat and the short duration of the change." (*Id.*) The EIR presents no biological or scientific rationale to support this conclusion. In fact, the scientific and biological facts mandate the opposite. Removing a quarter of the available cold water from the lake during the critical summer period is not relatively small - it is substantial. The EIR provides no data or support for the concept that this large percentage change in available cold water habitat will not have an adverse effect on the coldwater habitat / fish beneficial uses of Lake Almanor. (<u>See additional discussion in Attachments 1 and 2</u>)

C. <u>Wildlife</u>

1. Outdated, Inconsistent Baseline

The EIR uses obsolete data in its wildlife impacts analyses. It states that "Each species on the list was assessed for its potential to occur in the biological study area based on the species' known distribution and habitat requirements... and surveys of portions of the biological study area. Garcia and Associates conducted focused plant and wildlife surveys in portions of the biological study area in support of PG&E's application to FERC (PG&E 2002a). Supplemental surveys were not conducted during preparation of this section." (EIR at 6.7-7.) The use of 2002 survey data is inconsistent with the 2005 baseline and also grossly outdated for use in biological impact analyses for an action that will be implemented in 2016 or later. Also, the EIR fails to adequately describe these surveys, their duration, timing, frequency, and methods and therefore the County and the public cannot assess the adequacy or effectiveness of these surveys. Supplemental, updates surveys should be conducted and their methods and results fully described in the EIR.

2. Improper Limitation On Scope Of Analysis

The EIR's wildlife and vegetation analyses make a distinction between the biological study area and the activity area, but the EIR does not explain or define the difference or provide any rationale for why this is a biologically significant distinction. The vague and undefined term "activity area" is used in the EIR to improperly eliminate analyses of potential impacts to species that occur in the area that may be affected by implementation of the proposed project or Alternatives 1 and 2.

3. Improper Exclusion Of Analysis Of More Common Species

The EIR also improperly limits its analysis of impacts to only species that are listed as sensitive or special-status. This fails to disclose the full environmental impacts of the project or alert the public to other environmental effect they may be concerned about. Wildlife such as birds, mammals, amphibians and other species that are not listed as sensitive or threatened but which are present in the area should still be identified and potential impacts to them discussed. For example, if increased releases down the Seneca reach would greatly impair breeding opportunities or otherwise disrupt a common frog species, that effect should be disclosed in the EIR. The EIR here is defective in failing to even assess whether populations of these species are present in the affected area and in failing to disclose or analyze any possible impact implicated by such occurrence.

4. Frogs

The EIR's reliance on 2001 surveys for mountain yellow-legged frog is inadequate. Same comment for Cascades frog and foothill yellow-legged frog. General distribution maps indicate these species may be present in the area affected by the project. (See Attachment 11.) Also, at what time of year and where were the 2001 surveys conducted? How can the EIR conclude there will be no impacts to these species?

5. Willow Flycatcher

The EIR improperly fails to analyze Willow flycatcher as a species that may be affected by the Alternatives 1 and 2 by claiming that suitable habitat for this species is not present in the study area. However, the SWRCB's own January 12, 2006 letter regarding the Willow flycatcher, which was submitted to FERC as part of its National Environmental Policy Act process, states that the Lake Almanor area is a breeding stronghold for the species and that there may be potential impacts to this species from the proposed project alternatives that need to be assessed (and possibly mitigated). (See Attachment 4). The State Board even assured FERC that it would evaluate these important issues in this EIR. The County incorporates the State

Board's comments in its letter here and asks that the EIR perform the analyses and address the issues identified in the letter and then recirculate the EIR.

6. Western Red Bat

The EIR's failure to assess impacts to Western red bat on the basis that "[r]iparian habitat is not present in the activity areas" is inconsistent with the EIR's description of the environmental setting (i.e., baseline), which states "riparian [vegetation] communities are found adjacent to the North Fork Feather River in the Seneca and Belden reaches from Canyon Dam downstream to the Belden powerhouse and along Butt Creek." (EIR at 6.7-3.)

7. Wetlands

The EIR's analysis of impacts to wetlands is insufficient and conclusory. The EIR should identify potential construction areas that will be part of implementation of the proposed project or alternatives and conduct wetlands delineations to assess and disclose any potential wetlands impacts along with determining their significance so the public can comment on them. This same lack of specificity regarding the extent of impacts renders the EIR's suggested future mitigation measures for wetland impacts vague and inadequate. For example, the EIR's mitigation provides no definitive measures that must be employed to protect wetlands, identifies no alternative sites, fails to assure that any such alternative sites even exist, and provides no quantitative or objective measures of performance or success for the mitigation. Therefore, the EIR's conclusion that this mitigation would render wetlands impacts less than significant is unsupported.

8. Construction Activities

The EIR finds that construction activities could temporarily alter the foraging or movement patterns of wildlife. (EIR at 6.7-31.) However, it claims this effect will be less than significant based solely on the rationale that "long-term impacts to wildlife movement are not anticipated." (*Id.*) There is no biological justification for this conclusion and the conclusion is unsupported. Short-term effects during critical periods for a particular species may have a very significant effect on that particular species. The impact of any particular effect on a species depends on the co-occurrence or intersection of the effect and numerous other biological factors including average lifespan and behavioral traits such as foraging, breeding, and movement ecology. Also, the EIR does not define what it means by so-called short-term effects. Are these effects minutes, hours, days, weeks, months, or years long? Finally, the EIR does not adequately describe many of the construction activities and implementation actions that are part of the proposed project or Alternatives 1 and 2, and so it has no factual basis for analyzing or making conclusions regarding the impacts of these activities. (See comments on inadequate project descriptions)

9. Seneca Flows

Finally, the EIR does not address the impacts to wildlife of increasing flows in the Seneca reach from 35 cfs to 250 cfs (as proposed in Alternative 1). How will greatly increasing the flow in this 10+ mile reach of river affect the ability of wildlife to cross this reach? The EIR admits that the increased flows may cause hazards for humans using that stretch of the river, but fails to acknowledge that similar risks may be presented to mammals and other wildlife that have grown accustomed to crossing that portion of the river at its much lower baseline flow of 35 cfs.

D. Recreation

The EIR recognizes that "recreation contact" is a designated beneficial use of Lake Almanor and that this designation includes "fishing." (EIR at 6.8-1.) However, the EIR nowhere analyzes the impact of Alternatives 1 and 2 to recreational fishing at Lake Almanor, even though it states that the Lake "receives approximately 1,214,000 visitors annually". (EIR at 6.8-5.) A significant percentage of those visits are to engage in recreational fishing at Lake Almanor or Butt Valley Reservoir. The EIR must include an analysis and determination of whether the recreational fishing impacts on Lake Almanor will be significant as a result of the proposed project or Alternatives 1 or 2. (See also Section XII.)

The EIR recognizes that this analysis is required and it even includes an analysis of the effects to "the quality of recreational fishing opportunities in the North Fork Feather River below Canyon dam," which concludes based on a 2001 survey of recreational fishermen that "flow modifications under the Proposed UNFFR Project and either alternative would not substantially affect fishing opportunities." (EIR at 6.8-10.) Oddly, however, although it analyzes effects on recreational fishing in the river, the EIR includes no analogous analysis of the effect on recreational fishing at Lake Almanor even though the stakes and impacts at the lake are much greater than in the river. The EIR's total lack of analysis of the recreational fishing impacts on Lake Almanor ignores one of the greatest impacts of the proposed Alternatives, which is the possibility of losing recreational fishing for coldwater species in Lake Almanor for several years, if not longer. Similarly, the EIR omits an analysis of the impacts of Alternatives 1 and 2 on recreational fishing in Butt Valley reservoir when the fishery in that lake will be adversely affected by the loss of the significant prey subsidy or input it currently receives through entrainment of wakasagi at Prattville. (See also related comments in Attachment 2.) The EIR's inconsistent level of review and its omission of these analyses violates law.

E. Aesthetics

The EIR's discussion of Impact AE-4 (new sources of light or glare at Lake Almanor or Butt Valley reservoir) is too vague and cursory to adequately disclose and alert the County and public to possible new permanent sources of nightime lighting that may affect lake views and other aesthetic values. The EIR states that "[a]ny lighting structures included in these new facilities or improvements would be similar to those existing under current conditions and would be subject to the same regulation." (EIR at 6.9-10.) This rationale is flawed and unsupported without further description of the existing conditions and the proposed new facilities. Whether the new facilities will be similar to existing facilities is not the only factor necessary to assess impacts. One key factor is how many new facilities there will be in relation to what exists now (e.g., will the increase be 1, 10, or 100%?). Thus the EIR needs to disclose and analyze the magnitude of proposed new development and lighting in relation to existing sources. Similarly, it is unclear what the EIR means by "subject to the same regulation." The EIR should specifically explain what is meant by "regulation," in the context of the analysis so that the County or other potential regulatory entities can be apprised of the potential need to "regulate" in the future.

F. <u>Cultural Resources</u>

The County encourages and supports the mandatory requirement that mitigation measure CR-2b be adhered to as part of the State Board's 401 certification.

G. <u>Utilities / Energy</u>

The EIR's Public Services and Utilities impacts analysis completely fails to address the impacts of reduced power generation from increased flows out of Canyon dam as compared to the 35 cfs baseline flows, particularly the increased flows proposed in Alternatives 1 and 2. The total lack of this discussion in the EIR's chapter analyzing utility effects obscures any such impact and prevents informed decision making and meaningful public participation.

H. <u>Noise</u>

The County agrees with the EIR's conclusion that impacts from construction activities associated with the alternatives considered in the EIR are potentially significant. However, the County disagrees that mitigation measure NO-1 is sufficient to support the EIR's conclusion that this impact will be mitigated to a less than significant level. Mitigation measure NO-1 calls for vague, undefined "noise reduction measures." The EIR provides no details on how much these measures will reduce the noise of construction equipment to ensure that the resulting noise level in decibels after implementation of these (unspecified) measures will be less than significant. Furthermore, the mitigation requirement to place stationary noise generating equipment far away from sensitive receptors is qualified by a requirement that this equipment will only be placed "as far away as feasible." This qualification totally undermines the EIR's conclusion that this measure will mitigate noise impacts to less than significant levels. In fact, it proves the opposite - that the SWRCB cannot ensure noise impacts can or will be mitigated to less than significant levels. Similarly, the mitigation element of orienting equipment to "minimize" noise impacts does not quantify the minimization required and therefore cannot support the EIR's conclusion that impacts will be reduced to less than significant levels.

In sum, mitigation measure NO-1 amounts to a promise to try to do what can be done to reduce noise impacts, but provides no assurances that a particular noise impact arising from construction will actually be reduced by enough to render that impact less than significant.

I. Fisheries

The EIR's analysis of potential impacts to fisheries is inadequate and not supported by substantial evidence. As part of its review of the EIR, the County commissioned expert Dr. Alice Rich to provide in-depth review of the EIR's fishery resource discussion, analyses, and conclusions in addition to providing general comments on the adequacy of the EIR. The final report and qualifications of Dr. Rich are attached as Attachment 2. The County fully incorporates those comments here and requests that the State Board separately respond to the issues raised by Dr. Rich, as well as to those provided below.

1. Inadequate Mitigation

As mitigation for a cold water fish die-off in Lake Almanor, the EIR proposes that PG&E will simply restock the lake with more cold water fish. The surveys and methods to detect a fish die-off require much more detail to ensure effectiveness and adequate public review. What kinds of surveys, how many, when, where? A detailed sampling protocol must be developed and disclosed for comment. The same goes for efforts to replace fish. What are the triggers for restocking? The species and numbers of fish to be stocked are not stated. Monitoring post-stocking to ensure survival of stocked fish is essential to gauge effectiveness but is not included in the EIR. Furthermore, the EIR ignores the significant time gap between a die-off and successful restocking; it fails to disclose that the fish that will be killed are several year old cold water trophy fish (~20 inches), but the fish to be stocked are yearlings from a hatchery. Other mitigation measures should be considered (see subsection 3 below).

2. Alternatives 1 and 2 Would Significantly Impact Butt Valley Reservoir

As more fully described in Dr. Alice Rich's report and as summarized here, the EIR's conclusion that implementation of the Project alternatives would not have a significant effect on the recreational fishery of Butt Valley reservoir as a result of reduced forage fish in the reservoir is not supported by substantial evidence. The EIR concludes that the thermal curtains at Prattville will not significantly affect the trophy fishery in Butt Valley Reservoir, yet the EIR admits that the thermal curtains will almost entirely prevent wakasagi (i.e., pond smelt) from being siphoned from Lake Almanor to Butt Valley Reservoir through Prattville.

The EIR admits that the current addition of pond smelt from Lake Almanor to Butt Valley through the existing Prattville intake has been and is a significant and important source of food for the trophy fish in Butt Valley reservoir. Nevertheless, the EIR claims that eliminating this input of wakasagi from Lake Almanor to Butt Valley will not cause a significant impact on the fishery in Butt Valley because there is a self-sustaining population of wakasagi in Butt Valley reservoir.

The EIR fails to account for the fact that the additional pond smelt from Lake Almanor increase the density of wakasagi in Butt Valley, thereby making it easier for fish in Butt Valley to find and eat wakasagi. The fact that wakasagi may be locally reproducing in Butt Valley is irrelevant. The key issue for impact analysis is how will the predator-prey dynamic change in Butt Valley reservoir if the thermal curtains are installed and the current supplemental addition of wakasagi from Lake Almanor is stopped. The EIR provides no analysis of the density of pond smelt with and without thermal curtains; absent such an analysis (or other analyses showing that the density of the alleged locally reproducing population of pond smelt is already sufficient to maintain the trophy fishery) the EIR's conclusion is not supported by science, biology, or logic.

3. Additional / Alternative Fish Mitigation Required For All Alternatives

The reports of both Drs. Johnston and Rich (Attachments 1 and 2) indicate that coldwater conditions and fish at Lake Almanor are already in a critical state. Thus, any reduction of cold water habitat could cause a significant impact and require mitigation. This even applies to the proposed project, which the EIR currently finds will have a less than significant impact, but which the County believes requires reevaluation, especially in light of future climate change effects to Lake Almanor water levels and temperatures. Therefore, the EIR should consider including additional or alternative measures of mitigation for the proposed project and alternatives that would increase or maintain suitable coldwater habitat during the critical period. Such measures include a speece cone for oxygenation of coldwater or the addition of additional cool water into Lake Almanor.

XII. The EIR Fails To Analyze Potential Indirect Environmental Impacts That Would Result From A Loss Of The Economic Benefits Of Coldwater Fishing On Lake Almanor

"In evaluating the significance of the environmental effect of a project, the lead agency shall consider direct physical changes in the environment which may be caused by the project and reasonably foreseeable indirect physical changes in the environment which may be caused by the project." (CEQA Guidelines, § 15064(d).) The CEQA Guidelines provide that "[i]f an alternative would cause one or more significant effects in addition to those that would be caused by the project as proposed," the significant effects of the alternative must be discussed. (Guidelines, § 15126.6(d), citing *County of Inyo v. City of Los Angeles* (1981) 124 Cal.App.3d 1.)

The Draft EIR ignores the indirect physical changes to the environment that are reasonably foreseeable effects of the Project alternatives. Specifically, the EIR fails to disclose or evaluate the potential indirect effects that will occur throughout the Project region due to the economic impacts resulting from impacts to fisheries. The CEQA Guidelines instruct that "[w]here a physical change is caused by economic or social effects of a project, the physical change may be regarded as a significant effect in the same manner as any other physical change resulting from the project." (CEQA Guidelines, § 15064(e).) Here, there is substantial evidence that Alternative 1 and Alternative 2 would impact fisheries throughout the region, particularly in Lake Almanor, and Butt Valley Reservoir and that effects on fisheries in turn will have significant effects on the regional economy, which is significantly based in part on the recreational fishery and other recreation use and visits to the lake. Impacts to this resource-dependent economy will have foreseeable physical effects, in the form of closed and abandoned businesses and residences, reductions in tax-base, and dependent public services. There is little doubt that in Plumas County and the surrounding region, effects to the recreational economy will cause physical changes in these resource-dependent communities.

The EIR concludes that Alternatives 1 and 2 will cause a significant impact on coldwater fish species in Lake Almanor that may result in a large-scale die off of these populations. The EIR suggests inadequate mitigation in the form of fish stocking. Other comments in this letter address the violations of CEQA committed by the EIR when addressing those fisheries issues and others (such as in Butt Valley Reservoir), but there is another related issue that requires attention – the resultant indirect effects to the human environment from the economic and socio-economic impacts of the loss of the Lake Almanor fishery and other degradation. In its present form, the EIR improperly omits an analysis and discussion of the indirect effects that will be caused by the reduction of economic activity that are reasonably foreseeable from the degradation of the Lake Almanor and Butt Valley under Alternatives 1 and 2.

CEQA requires the EIR to analyze and discuss the impacts to the human environment that could indirectly result from economic impacts caused by a proposed project or proposed alternatives. That requirement is met in this case. Specifically, the causal connection between a die-off of coldwater fish species and other degradation in Lake Almanor, to economic impacts, to resultant impacts on the human environment is straightforward. A fish die-off in Lake Almanor or Butt Valley and/or a decrease in fishing success or other recreational quality would substantially reduce the number of persons who visit the area for recreational fishing and reduce the dollars otherwise spent by such visitors within the County.

This loss of recreational fishing and other visitation would therefore reduce the income stream in Plumas County, particularly in the Lake Almanor and Butt Valley reservoir areas (e.g., Chester). This impact could last several years or longer because many of the fish that would be killed are several years old and represent the "trophy fish" that anglers prize and seek. The County explains elsewhere that the EIR's proffered mitigation measure of stocking hatchery fingerlings is wholly inadequate to replace this biological treasure. And so several fishing seasons or more will likely pass before anything close to resembling the original coldwater fisheries occur in Lake Almanor. Word of any fish die-off will spread quickly via social media and the web, and anglers will seek their trophy fish elsewhere.

The significance of recreational fishing and measures of calculating its role as an economic driver of surrounding communities has been well-established for many years and throughout the country. Included in this letter as Attachment 5 are numerous articles confirming the economic impact of recreational fishing and recreational visitorship to the surrounding, often rural communities. The County provides these articles and others provided additional attachments to establish that there exists an entire academic community of professional economists and researchers that have developed methodologies for calculating the relationship and impact of recreational users (and spending) and the economy of nearby communities. For instance, the report by Chen et al. (2003) demonstrates standard methods of measuring and quantifying economic impacts for a trophy largemouth bass fishery for Lake Fork, Texas. Others discuss various other locations and fisheries and the importance of recreational visitors to most rural communities.

There is even precedent for conducting such studies in Plumas County. Specifically, when the State contemplated pike eradication efforts at Lake Davis, the economic effect of recreational fishing at that lake were calculated and considered. The attached August 24, 2006 report by The Center for Economic Development at California State University Chico, calculated the value of the recreational fishery in that lake. (See Attachment 6.) The report concluded that the Lake Davis fishery was worth almost a million dollars annually in Plumas County income. Lake Davis is less than one-tenth the size of Lake Almanor, so the benefits of Lake Almanor are obviously much greater. Considering the life of the planning horizon evaluated in the EIR, the value of the Lake Almanor fishery is likely hundreds of millions of dollars. The Chico State report demonstrates the economic value recreational fishing brings to Plumas County. Attachment 7 to this letter includes information demonstrating that Plumas County's economy heavily and disproportionately relies on economic activity from visitation and travelers from outside the area (over 50% of local tax and transient occupancy receipts) that is generated by recreational fishing and other lake recreation.

In 2012, a significant forest fire affected much of Plumas County during the summer and seasonal visitation, which is generally highest in the summer months, was reduced as people avoided the fire and smoke that was prevalent in portions of the County. The County surveyed local businesses regarding the effects of the reduced recreational visits on their seasonal income (See Attachment 8.) The results demonstrated that businesses lost on average 53% of expected income as compared to the previous non-smoke year. The total loss of just a subset of businesses totaled $1.4 million. There has also been a study confirming that changes in Lake Almanor water level affect real estate values and possibly county and local tax receipts. (See Attachment 9.) Effects to lake levels from the proposed project and alternatives is another effect that the EIR does not adequately analyze, but which this study demonstrates can affect property values and consequently the local property tax base.

As part of its effort in responding to the EIR, the County contacted businesses and other service providers to ask how they might be affected by a loss or decrease in revenue from recreational fishing business. The responses the County received are contained in Attachment 10 to this letter.[5] They reveal alarming potential impacts to the local economy and subsequent physical changes to the human environment. These data justify and demand that the State Board conduct a more thorough analysis of these issues and disclose them to the public and decision makers in the EIR. For instance, Linda Wagner, Chief Executive Officer of the Seneca Healthcare District, a district hospital (and the only hospital) in Chester declares that it currently struggles to achieve a net positive income and that it relies heavily on the local tax base, which has declined over the years. She states that any further decrease in this local tax increment finding "would jeopardize our ability to provide health care in the community." Secondly, she states that the hospital relies on revenue from increased visits in the summer (from seasonal residents and tourists) to carry the hospital through negative cash flow winter months. Based on her observations and experience at the hospital, she states the hospital is "very much dependent" on Lake Almanor's effect on the population and visitation "to support the health care service provided to the community," and without Lake Almanor "access to healthcare in this area could be put at risk."

Joe Waterman, General Manager and Chief of the Chester Public Utility District and Chester Fire Department, respectively, declares that any reduction in property values will reduce the tax base and affect the provision of local services such as fire protection, water delivery, wastewater treatment, solid waste management, and streetlight provision. He states that the District already has a significant amount of funding unavailable to it because of defaults in assessments and taxes and "cannot afford any impacts that would increase the default rates we are experiencing." He also states that fire and ambulance services "rely heavily on volunteer firefighters to operate effectively" and that any reduced tourism, loss of employment that encourage population decline will have a drastic effect on the District's ability to provide services.

Numerous other residents and businesses have also commented on their high reliance on the recreational and recreational fishing economy and the potential for business closures, loss of revenue, reduced property values and decreased visitation that a fish die-off or water quality impacts like algal blooms or swimmer's itch at Lake Almanor would cause. These statements confirm the possibility of boarded up and closed shops blighting Chester, loss of services such as

---

[5] Although, the County has collected all these comments and submits them here in support of its comment letter, the State Board should also consider each individual comment a separate comment from the named individuals for purposes of party exhaustion of administrative remedies because the individuals that submitted these comments to the County were under the impression that they were providing public comments on the EIR, and that the County was acting as an intermediary for them and would timely forward their comments to the State Board, which the County has done.

24 hour gas stations or emergency tow services, and snow removal by private residents. This would cause aesthetic and safety impacts. Closure of some of the privately-owned recreational campgrounds could cause overcrowding or increased use and deterioration at other public campgrounds or illegal overnight camping on public lands with attendant environmental and aesthetic impacts such as trash, pollution (e.g., emptying grey water etc.), and compaction and destruction of vegetation.

As one of the premier recreational and fishing lakes in the northern Sierra and the largest in Plumas County, the economic significance and benefits of out-of-area visitors to Lake Almanor is undisputable. The EIR recognizes the significance of Lake Almanor in several places. Yet, the EIR nowhere provides any discussion or analysis of the grave and significant adverse economic effects and resultant indirect physical effects implementation of Alternatives 1 and 2 could cause. These are not mere economic impacts, but actual, physical indirect impacts on the human environment that must be considered under CEQA.

XIII. Cumulative Impacts And Climate Change

The EIR's cumulative impact analysis is deficient in failing to address the effect of climate change on the proposed project and alternatives over the life of the project (i.e., relicensing period of 40-50 years). The analysis period must match the life of the project, so here it is necessary and useful to consider what is foreseeable regarding climate change and water temperatures in 20 or 30 years. The data demonstrate a significant trend of warmer and reduced flows in the watershed in the past decades as compared to earlier historical data that is expected to continue. (See Attachment 3.) The EIR fails to analyze the impacts of the proposed project and Alternatives 1 and 2 in light of this trend and how they will impact resources and perform in this climate-changed future environment. Failure to do so violates CEQA. It provides an incomplete and erroneous assessment of environmental impacts and the efficacy of Alternatives 1 and 2. The County believes such an analysis could show that with climate change, Alternatives 1 and 2 will not achieve their intended purposes. Similarly, it might reveal that impacts from the proposed project or Alternatives 1 and 2 on coldwater fish in Lake Almanor will be even worse. It is essential for the State Board and public to know the results of this kind of analysis to determine whether additional mitigation (such as methods to oxygenate coldwater or increase the volume of coldwater in Lake Almanor) will be necessary in the future.

XIV. CONCLUSION

Plumas County implores the State Board to conduct a more informed, thorough, and objective analysis of the true impacts and trade-offs of potentially sacrificing the environment of Lake Almanor and surrounding communities in an effort to achieve a temperature reduction in the lower river with dubious and uncertain biological benefits and justification. An analysis by a fisheries expert prepared for the FERC process confirms that this is the choice presented to the State Board and his report concluded, as any rational person would, that it was unwise and unwarranted to knowingly and with certainty adversely and significantly impact Lake Almanor for speculative and uncertain benefits downstream. (See Attachment 14.) Plumas County asks the State Water Board to exercise its regulatory power in a rational, balanced, and equitable manner that examines the relationship between temperature conditions in the Feather River and the Project, and that considers and evaluates alternatives that would avoid the impacts of the alternatives proposed in the Draft EIR. Given the delicate balance at the lake and the likely increased stresses the climate change will bring even under the proposed project, the County believes other mitigation and monitoring measures should be included even if the proposed project is selected. This is what is required under state and federal law and the State Board's regulations, policies, and authority.

In its current state, the EIR does not meet CEQA standards. The Draft EIR fails to perform its task as an informational document to foster informed decision-making, public involvement, and public accountability. The errors and short-comings in the EIR prevent meaningful public participation and an accurate understanding of the environmental impacts associated with the Project and the Project alternatives. These same flaws render the EIR inadequate to support a certification decision by the State Water Board. The State Board should revise and improve the EIR as indicated in this letter and then recirculate the new analyses for public comment and review.

Thank you,

Kevin Goss, Chair

Plumas County Board of Supervisors

1235184.1 9203-003

ATTACHMENT 1

Comments on Draft Environmental Impact Report for the Water Quality Certification of Pacific Gas and Electric Company's Upper North Fork Feather River Hydroelectric Project (FERC Project No. 2105):

Section 6.5 Water Quality: Analysis and Comments,

Dr. Gina Johnston, Professor Emerita, CSU, Chico

Overview

This is a review of section 6.5, Water Quality, of the Draft Environmental Impact Report prepared by the State Water Resources Control Board in response to Pacific Gas and Electric Company's application for a water quality certification for operation of its Upper North Fork Feather River Hydroelectric Project (UNFFR Project) under a new license. The proposed project is composed of elements of PG&E's application to FERC along with modifications. Because of unresolved water quality issues, primarily the elevated water temperatures in the North Fork Feather River upstream of Lake Oroville, the State Water Board has included:

Alternative 1: thermal curtains at Prattville Intake and Caribou Intakes and the release of 250 cubic feet per second (cfs) to Seneca Reach between June 15 and September 15.

Alternative 2: thermal curtains at Prattville Intake and Caribou Intakes.

Question: Why were the following topics omitted from discussion when they will affect or be affected by the project?

Water Visibility

The proposed UNFFR Project and the alternatives will result in warming of Lake Almanor. This could promote the growth of algae, particularly blue-green species. This would reduce visibility of the water. Our data shows that large populations of algae are produced when the lake is warm and nutrients are available in the fall (Johnston and McReynolds, 2015).

Global Climate Change

While the proposed UNFFR Project and alternatives may not affect the trends in water temperatures of Lake Almanor, climate change will certainly have an impact on the success of any project that depends on the existence of a coldwater resource and the transport of that cold water downstream. Climate change in California will result in higher temperatures, decreasing precipitation, a shift to precipitation falling as rain rather than snow and a decrease in Sierra Nevada snowpack by as much as 70 to 90% (California Climate Change Center, 2006; CA EPA, 2013). It is highly likely that climate change will result in even higher water temperatures throughout the Feather River system than exist today. The EIR did not address whether climate change is even partially responsible for higher temperatures in the NFFR downstream of Lake Almanor. However, data show that it is having an effect throughout the west. The impact of climate change on the seasonal cycles in streams in the Pacific Northwest has caused less snow in the winter snowpack, decreased water flow in summer, changes in the temperature of flowing water and warmer air temperatures above the streams (Oregon Climate Change Research Institute, 2013).

Climate change is also increasing the rate of cultural eutrophication (Havens, 2015). Higher water temperatures favor algal growth, especially toxic blue-green algae (USEPA, 2015; Kovner, 2013). Our data for Lake Almanor show that summer algal populations have been increasing and large populations of blue-green algae in August and September are already a concern (Johnston and McMurtry, 2014; Johnston and McReynolds, 2015).

Nutrients

The proposed UNFFR Project, as well as Alternatives 1 and 2, may cause a detrimental change in the overall concentrations of nutrients due to mixing in the hypolimnion and lower metalimnion induced by the withdrawal of hypolimnetic water from Lake Almanor. Modeling of the thermocline elevation during a critically dry year predicts that the thermocline could be deepened by as much as 3-7 feet over the course of the summer (Appendix E-1, Table 8). This could cause mixing of the nutrient-rich hypolimnetic water with the epilimnetic water above, where algae are photosynthesizing, resulting in algal blooms. Our data show that in late August and early September the thermocline in Lake Almanor is only about 2 meters (6.6 feet) in extent (Johnston and McMurtry, 2009; Johnston and McReynolds, 2015). The mixing in the hypolimnion due to withdrawal may increase the amount of nutrients available to algae at a time when sunlight and warmer water temperatures are ideal for growth. Since algal growth is limited by the availability of nutrients at this time of year, increased nutrients will increase algal growth.

Nutrients will also be sent into Butt Valley Reservoir and Seneca Reach. The effects of these nutrients released from Lake Almanor in the hypolimnetic water has not been addressed.

6.5.1 Environmental Setting and Water Quality Conditions of Concern

Question: Is coldwater habitat in Lake Almanor impaired and would this project or alternatives increase impairment?

While Lake Almanor generally meets water quality objectives, the decrease in coldwater habitat during warm critically dry years is significant and increasing in temporal and spatial extent. Analyses of surface temperatures in other California lakes have shown warming (Schneider et al, 2009; California EPA, 2009; Kovner, 2013) and this is mostly likely happening at Lake Almanor, as well. Surface temperatures at Station LA-01, near Canyon Dam, were warmer in July 2014 than they were in 2009 (Johnston and McMurtry, 2009, 2014). Also noted was an increase of 2°C in the temperature of NFFR water at Chester, CA from 2009 to 2014. The changes in overall climate, the subsequent change in snow -water content, and shifts in precipitation from snow to rain that are predicted for California (Scripps, 2013) will further decrease the limited coldwater resource at Lake Almanor. PGE's data for 2008 and our data for 2014 (both critically dry years) showed that thermal stratification was established sooner, epilimnion temperatures were warmer, and the stratification persisted until the end of October. Our data also showed that algal production was very high, but oxygen concentration dropped rapidly to zero in the thermocline. The result was essentially no coldwater habitat in August and September. Unfortunately, anthropogenic warming is increasing the probability of co-occurring warm-dry conditions that have created the current drought (Diffenbaugh et al, 2015).

It is imperative that the depletion of oxygen in the deepest areas of the lake and the resulting lack of suitable coldwater habitat be considered as an indication of water quality impairment. The calculation of habitat reduction was made in the Stetson Report (2009). Those calculations were based on data from 1984-2002, which is not representative of actual conditions and trends evident over the past 10 years and operating in the Lake today. Key water quality conditions at Lake Almanor have worsened. Appendix E1, Table 12, shows there is no suitable habitat for the month of August under both current and proposed UNFFR Project conditions. Our data indicate that lack of habitat now extends well into September (Johnston and McReynolds, 2015). On September 10, 2014 the epilimnion extended down to 10 meters (33 feet) and was at 21°C. Oxygen was at 6 mg/L. At 12 meters the temperature had dropped to 16°C, but the oxygen had dropped to zero and was zero throughout the hypolimnion. A continuous temperature data logger at LA-01 near Canyon Dam showed that thermal stratification persisted until the end of October (Johnston and McReynolds, 2015).

In a normal water year there would still be a considerable reduction (-3,490 AF) of suitable habitat volume (Appendix E1-Table 9) in August with implementation of the proposed UNFFR Project, but nearly three times the impact with Alternative 1 (-10,420 AF) or Alternative 2 (-9,370 AF). Our data for 2011 (the closest year to a normal water year since our monitoring began)) shows that in September the reservoir was still stratified with no oxygen in the hypolimnion. The epilimnion was at 22°C and extended down to 10 meters. At 12 meters oxygen was at 3mg/L and dropped to zero below that depth (Johnston and McMurtry, 2012).

Our data show that the coldwater habitat is currently impaired in the summer and this project or alternatives will increase that impairment by removal of cold water. The proposed UNFFR Project should have a mitigation measure that addresses the impairment and improves coldwater habitat

Question: would water withdrawn from the hypolimnion of Lake Almanor affect the quality of water downstream or in Butt Valley Reservoir?

If water is withdrawn from the hypolimnion as described for the Proposed UNFFR Project, as well as Alternative 1, a "cocktail" of trace metals, along with nitrogen and phosphorus compounds will be sent downstream. The amount will depend on the duration of the flow as well as the rate. Water samples from the hypolimnion at LA-01 near Canyon Dam were collected on four dates in 2014. In September, after a few months of thermal stratification and the resulting anoxic conditions, elevated levels of aluminum, arsenic, copper, iron, manganese, mercury and zinc were detected. Also present were nitrogen-containing compounds (ammonia, nitrite, nitrate, etc.) and phosphorus-containing compounds (Johnston and McReynolds, 2015). With greater withdrawal and discharge to the Seneca Reach, some of these compounds would be adsorbed onto sediments of the Seneca Reach, but not all. Some would be transported and could affect water quality in the water bodies downstream. Many studies of trace metal transport show that the mobility depends on several factors including abundance, reactivity and hydrology (Nordstrom, 2011). Higher flows in the Seneca Reach will result in increased transport of metals, as well as sediment, downstream. Nitrogen compounds are very soluble, so they would not be adsorbed onto sediments. Phosphorus compounds would also be present as dissolved and particulate components and transported (Ruttenberg, 2003). Hydrogen sulfide, a common ingredient in the hypolimnetic water, would be at higher levels with increased discharge through the lower gates of Canyon Dam.

If Alternative 1 or 2 is implemented, Butt Valley Reservoir will receive hypolimnetic water from Lake Almanor. As stated above, this water will be devoid of oxygen and will have elevated levels of several trace metals, along with nitrogen and phosphorus compounds. Because of its lower temperature it will sink to the bottom of the reservoir. Simulations of the impact of Alternatives 1 and 2 on the suitable habitat (temperature $\leq 20°c$, oxygen $\geq 5mg/L$) during a critically dry year shows that no such habitat exists from mid-July until mixing occurs in September (Appendix E-1, Table 20). The metals and nutrients will be transported downstream and could have an impact in those water bodies.

It should further be stressed that withdrawal of cold water by alternative 1 or 2 will be sufficient to result in a warmer Lake Almanor. Mixing of the hypolimnetic water with the metalimnion or epilimnion will generally warm the upper hypolimnion. This may result in a warmer water column at turnover. Warmer temperatures generally encourage the growth of algae (Konopkai and Brock, 1978; Donath, 2013;Valentine, 2015), particularly blue-green species. Overturn is the time of greatest algal growth at Lake Almanor and warmer temperatures in conjunction with increased nutrient availability will increase that growth (Johnston and McReynolds, 2015). Increased algal growth will interfere with water contact recreation, another beneficial use.

6.5.2 Environmental Impacts and Mitigation Measures

Question: will the proposed UNFFR Project or the alternatives result in substantial water quality changes that would adversely affect beneficial uses?

WQ – 1: Implementation of the UNFFR Project could affect water temperature in Lake Almanor

Proposed UNFFR Project

The DEIR states that increased releases from Canyon Dam could affect distribution of water temperatures during the period of summer thermal stratification. The magnitude of the effects is based on the results of the Level 3 Report by Stetson Engineers (2009). This analysis used data from 1984-2002, which may not adequately represent thermal conditions today. Plumas County Flood Control and Water Conservation District, through the efforts of an advisory group, has conducted basic limnological studies from 2009-2014. (Copies of the reports for 2011-2015 have been sent to Peter Barnes, SWRCB, in a packet from Lake Almanor Watershed Group.) These studies show that the onset of thermal stratification is occurring earlier and persisting longer than in 2002. Data from a continuous temperature data logger located near Canyon Dam show that thermal stratification lasted until the end of October 2014. The assumption that the reduction in suitable habitat due to hypolimnetic withdrawal is limited to August (thus, short-lived) is incorrect.

The DEIR states that in a critically dry water year, Lake Almanor is already devoid of suitable coldwater habitat by August (page 6.5-17). The only way that impact assessment could be conducted was to raise the water temperature criterion to 21°C. Table 13 (Appendix E-1) shows that this takes the marginal coldwater habitat from 4% to 3% of the total reservoir storage, or a change of 25%. In a critically dry year such as 2014, there may be another two months before thermal stratification disappears, so this is neither a small change nor is it of short duration.

The DEIR concludes that under all water year types, the proposed UNFFR Project could increase the suitable habitat volume in September and early October. Our data show that this would not occur because the lake would still be strongly stratified until at least mid-September and cold-water withdrawal will continue until mid-September. The only way that habitat could be increased is if the thermal stratification were to be disturbed by hypolimnetic withdrawal, resulting in destruction of the coldwater pool.

The DEIR states that on a lakewide basis the proposed UNFFR Project could result in a reduction of less than one percent of suitable habitat volume. Therefore the impact on water temperature would be less than significant. However, the report states that in a normal water year, the reduction would about 7.9 % and in a critically dry water year, there is no suitable habitat available, at all. The report conclusion is not supported by the analysis presented. The obvious conclusion is that the proposed UNFFR Project would further decrease an already compromised coldwater habitat. Even in a normal water year the coldwater habitat would be 5% of the total lake volume in mid-August. Therefore, the report conclusion should be that implementation of the proposed UNFFR Project will result in substantial water quality changes that would adversely affect beneficial uses. The proposed UNFFR Project should also include a mitigation measure that addresses the reduction in coldwater fish habitat and seeks to improve or increase habitat.

Alternative 1

The operation of a thermal curtain at the Prattville intake could induce mixing at the interface of the hypolimnion and thermocline, as well as in the hypolimnion, itself. Our sampling program for 2012 included a sampling station (LA-07) in the vicinity of the proposed thermal curtain. In early September 2012, the epilimnion extended to more than 10 meters (33 feet). The deepest point was at 16 meters (53 feet) and was at 10.3°C, but the water at the thermocline, 12 meters depth, was considerably warmer at 17.5°C. The entire metalimnion was only 4 meters in extent and the hypolimnion was only 2 meters in extent (Johnston and McMurtry, 2013). In order to maximize the operation of the thermal curtain, water must be drawn from as deep as possible, which will increase the likelihood of mixing in the hypolimnion and the introduction of nutrients and trace metals into the thermocline and possibly the epilimnion. This could result in algal blooms since nutrients would be made available to algae. It is well known that algae will respond to inputs of nutrients (Hecky and Kilham, 1988).

As was previously discussed, the withdrawal of hypolimnetic water from Canyon Dam would have the same effect on mixing at the metalimnion-hypolimnion interface and in the hypolimnion, as well. This would introduce nutrients and metals into the upper metalimnion (thermocline), stimulating algal growth. During the six years of our study (2009-2014), the greatest algal abundance has been at overturn when the nutrients from the hypolimnion are mixed into the entire water column. Typically, algal populations are low during the summer because nutrients are trapped in the hypolimnion. Any disturbance of the thermal stratification could increase nutrient supply and algal growth.

Operation of the thermal curtain at Prattville and withdrawal of hypolimnetic water at Canyon Dam will result in a further decrease of suitable coldwater habitat beyond the proposed UNFFR Project discussed above. In a normal water year suitable habitat volume would be reduced by about 10,420 AF, compared to current conditions. The report concludes that this is a small change in volume and that it would be of short duration. This would reduce the total suitable habitat from 5% to 4% of the lake's total volume. This is not a reduction of 1%, as the report states, but actually greater than 20% reduction. It would also not be of short duration, but would last as long as the end of September.

In a critically dry water year there would be no suitable habitat from mid-July until the end of September. There would a reduction of even marginally suitable habitat by 50% (from 4% of the total lake volume to 2%). The report concludes that the impact would be significant without mitigation.

Because Butt Valley Reservoir would receive hypolimnetic water withdrawn from Lake Almanor, the water would be devoid of oxygen and would contain particulate and dissolved trace metals, as well as nitrogen and phosphorus compounds. Since this reservoir is shallow and poorly stratified, mixing could occur as this water leaves the Butt Valley powerhouse and deliver additional nutrients to the algae downstream. Metals could become incorporated into the food chain and concentrate in the fish.

Alternative 2

A thermal curtain at the Prattville Intake without increased releases through Canyon Dam would have similar effects on suitable coldwater habitat volume. During a normal water year, the decrease in habitat would be from 5% (baseline or present day value) to 4% with alternative 2. It must be stressed that this is not a decrease of 1%, but rather a decrease of 20%, and a habitat volume of only 4% of the total lake volume is extremely small and fragile.

In critically dry years, no suitable habitat exists, and marginal habitat is 10% or less of total lake volume from mid-July until mid-September, according to our data (Johnston and McReynolds, 2015). The DEIR concludes that the effects would be significant without mitigation.

No data are presented to estimate the impacts on suitable habitat in Butt Valley, except that generally the coldwater habitat would be increased. However, the water quality would be decreased by the nutrients and metals carried from the hypolimnion of Lake Almanor.

Our data indicate that the proposed UNFFR Project or the alternatives will result in substantial water quality changes that will adversely affect beneficial uses.

Mitigation Measure WQ-1

Question: Considering that the proposed project and alternatives will have significant effects, is the proposed mitigation measure appropriate? How would the mitigation measure reduce impact to a less than significant level?

The DEIR concludes that the proposed UNFFR Project, as well as Alternative 1 and 2, will have a significant impact on the volume of suitable coldwater habitat during mid-July through August of critically dry years unless mitigation reduces that impact. This is because suitable habitat is not even present in the lake. The proposed mitigation of temperature monitoring and augmented stocking of coldwater fish following critically dry water years would just increase competition for a limited resource. No evidence is presented that restocking will improve the ability of the coldwater fishery to recover. No evidence is presented to explain how this would reduce the project impact on the coldwater habitat.

A more appropriate mitigation for the proposed UNFFR Project would actually increase coldwater habitat, reduce thermal stress and reduce overcrowding of coldwater species. The installation of a Speece Cone, such as has been installed at Comanche Reservoir, would oxygenate the hypolimnion without disturbing the thermal stratification. This would allow coldwater fish to utilize this portion of the lake during the summer months and it would prevent release of nutrients and hydrogen sulfide from the sediments. Such a mitigation measure should be required for the UNFFR Project, as proposed in the State Water Board Staff Recommendation.

Comanche Reservoir, where a Speece Cone has been operating for more than 20 years, is less than half of the volume of Lake Almanor and 135 feet maximum depth. Prior to installation it was plagued with an anoxic hypolimnion, fish kills and hydrogen sulfide generation in the sediments. Hypolimnetic oxygenation was selected as the best alternative to balance the coldwater fishery with water supply needs. The oxygen plume from the Speece Cone extends out as much as 3 miles into the reservoir and maintains oxygen concentration at 6 mg/L (Mello, 2014; Beutel and Horne, 1999).

Although installation of a Speece Cone will increase habitat for coldwater fish species in Lake Almanor, the lake will still be warmer, since cold water will be withdrawn from June –September at an increased rate.

Our data indicate that because there is no suitable coldwater habitat in Lake Almanor during summer of critically dry years, restocking the lake will not reduce the impact of the project to a less than significant level.

Impact WQ-2: Implementation of the UNFFR Project could affect water temperature in Butt Valley Reservoir

Question: Are there other measures that could achieve reduced water temperatures in Butt Valley Reservoir besides a thermal curtain and have they been considered?

Since the proposed UNFFR Project would result in increased flows through Canyon Dam and decreased flows though the Prattville Intake, the temperature in Butt Valley Reservoir would be increased in the summer. In a critically dry water year, this increase could be significant, since the temperature of the epilimnion of Lake Almanor would also be increased. Preferential use of Caribou No.1 powerhouse, as well as insulation and shading of the penstocks into the Butt Valley powerhouse and those into the Belden forebay, would help preserve the cooler water temperature. Also, reduction of the Butt Valley powerhouse discharge to about 500 cfs can cause selective withdrawal of hypolimnion cold water at the Prattville Intake, as was demonstrated during a 2006 special test (Stetson Engineers and PG&E, 2007a).

Alternatives 1 and 2

Both alternatives 1 and 2 would decrease water temperatures in Butt Valley Reservoir, since they would withdraw hypolimnion water from Lake Almanor. However, as discussed above, decreased water temperatures in Butt Valley Reservoir can be achieved in other ways that would be less disruptive to Lake Almanor.

Impact WQ-3: Implementation of the UNFFR Project could affect water temperatures in the North Fork Feather below Canyon Dam and Belden Dam.

Question: Will the proposed UNFFR Project achieve the desired water temperature in the downstream reaches? Will the installation of thermal curtains achieve the desired water temperature in the downstream reaches? Are there other approaches that would decrease temperature as much but have less impact on Lake Almanor?

The DEIR concludes that the proposed UNFFR Project will still result in water temperatures that exceed the optimal temperatures for rainbow trout in summer months in the Belden and Rock Creek reaches.

Alternative 1

With the combination of thermal curtains and increased Canyon Dam discharges, MWATs would continue to exceed 20°C along portions of the Rock Creek and Cresta reaches in critically dry water years. More than half of the Poe reach would remain above 20°C during summer months. Much of the increase in water temperature is due to the warmer East Branch of the North Fork Feather River, which enters above the Belden powerhouse. Obviously, revegetation or shading to reduce temperature in the East Branch should be implemented prior to construction of thermal curtains.

Alternative 1, while placing the coldwater habitat of lake Almanor in serious jeopardy, "would not be sufficient to eliminate the occurrence of exceedances of 25°C diel fluctuations for the Poe reach during warm summer months of dry and critically dry years..." (DEIR, page 6.5-22).

Alternative 2 could result in diel fluctuations of water temperature that reach or exceed lethal levels for coldwater species in the Poe reach.

The conclusion is that alternatives 1 and 2 will be very disruptive to the Lake Almanor ecosystem, but they may not achieve the objective of sufficient cooling in the lower reaches. If warming of the system due to climate change is considered, this casts further doubt on achieving this objective.

Impact WQ-4 Implementation of the UNFFR Project could affect DO concentration in water discharged from Canyon Dam and Butt Valley powerhouse.

Since these discharges would be hypolimnetic water from Lake Almanor, they would be devoid of oxygen for most of the summer months. The Use of a Speece Cone at Canyon Dam would result in oxygenated water releases into the Seneca Reach.

It is possible that a Speece Cone at Canyon Dam would have effects as far as the Prattville Intake. A combination of a Speece Cone at Canyon Dam and reduced flow at Prattville Intake could achieve improved water quality at Lake Almanor and Butt Valley Reservoir, as well as decreased temperatures downstream.

Impact WQ-5 Implementation of the UNFFR Project could cause water released from Canyon Dam to have an undesirable taste or odor.

Impact WQ- 6 Implementation of the UNFFR Project could cause a change in the character or quantity of dissolved metal concentrations or other contaminants in Lake Almanor or the North Fork Feather River.

Question: Has the transport and biological impact of trace metals, nutrients and sediment on downstream reaches and Oroville Reservoir been seriously considered?

As discussed in the DEIR (page 6.5-26), increased withdrawal from the outlet gate would result in considerable mixing and possible dilution of the sulfide-containing hypolimnetic water. Mixing could also increase transport across the sediment-water interface. Nutrients and trace metals would be distributed throughout the hypolimnion, not just at the sediment-water interface. Therefore, withdrawal will result in transport of hydrogen sulfide, trace metals and nutrients to the Seneca Reach. Our data (Johnston and McReynolds, 2015) have shown that nutrients and trace metals are relatively high in Hamilton Branch below Mountain Meadows Reservoir. Nutrients, as well as iron and other trace metals accumulate in the hypolimnion at LA-01, near Canyon Dam.

Installation of a Speece Cone would have the benefit of preventing the release of hydrogen sulfide and nutrients from the sediments. That coupled with increased flows as needed from Canyon Dam should be considered instead of thermal curtains.

The DEIR does not consider the impact of transport of trace metals, nutrients and sediment on downstream reaches or Lake Oroville. Further study is needed to determine if these components will have an impact on water quality or the fish populations.

Summary

The DEIR and our data document that suitable coldwater habitat in Lake Almanor and Butt Valley Reservoir is already impaired. The proposed UNFFR project will further jeopardize that resource and Alternatives 1 and 2 will only increase that impact. The only proposed mitigation measure of increased temperature monitoring and increased stocking of coldwater species will do nothing to alleviate the impact.

The DEIR predicts that the proposed UNFFR project will not achieve the necessary decrease in water temperature in the Belden and Rock Creek reaches and water temperatures would still exceed the 20°C threshold in summer months.

In the summer months of dry and critically dry water years, alternatives 1 and 2 would still not produce water temperatures of 20°C or less in more than half of the Poe reach.

Mixing due to removal of cold water from the hypolimnion of Lake Almanor could result in increased nutrients in the thermocline or epilimnion and increased algal growth, further deteriorating water quality. Transport of trace metals, sediment and nutrients to downstream reaches could impact their water quality.

Measures such as increased flow through Canyon Dam, insulation and shading of penstocks throughout the UNFFR system, reduced flow through Prattville Intake to encourage hypolimnetic withdrawal, preferential use of Caribou #1 intake and revegetation and shading of streams should all be implemented prior to consideration of thermal curtain construction. A mitigation measure, such as installation of a Speece Cone, should be implemented for the proposed UNFFR Project to improve coldwater habitat. This measure would still not be sufficient to mitigate the impacts on the coldwater habitat of alternative 1 and 2 because the high rates of withdrawal they would require.

Questions Concerning State Water Board Staff Recommendation

Although the State Water Board staff has developed a preliminary recommendation that will allow the implementation of the proposed UNFFR project with increased releases from June 15 to September 15, their own DEIR has concluded that this project will not achieve sufficient water temperature decreases.

1. What will constitute the monitoring program? Who will design it?
   A monitoring program should include temperature, dissolved oxygen, trace metals and nutrients at multiple locations in the two reservoirs and in inflowing streams and the NFFR and at multiple times during the year. Any monitoring program should be designed with input from Plumas County, Department of Water Resources and Department of Fish and Wildlife.
2. At what point will sufficient monitoring be completed to show that elevated water temperatures are still occurring in the NFFR?
   The State Water Board will reserve the right to require installation of thermal curtains based on monitoring results. However, the DEIR already predicts that thermal curtains will be necessary to achieve temperature reductions in the Belden and Poe reaches. No other means of temperature reduction have been considered in the DEIR. Although no details are given for how much monitoring will be necessary, the data showing increased water temperatures in the North Fork Feather River already exist, so installation could be required at any time.
3. What will constitute "adaptive management", as suggested by the Staff alternative, and who will be involved in planning and implementation?

References

1. Beutel, Marc W. and Alex J. Horne. 1999. A review of the effects of hypolimnetic oxygenation on lake and reservoir water quality. Lake and Reservoir Mgmt. 12/1999: 15(4) 285-297.
2. California Climate Change Center, 2006. Our Changing Climate: Assessing the Risks to California.
   http://meteora.ucsd.edu/cap/pdffiles/CA_climate_Scenarios.pdf

4. California Environmental Protection Agency, 2013. Indicators of Climate Change in California.
   http://oehha.ca.gov/multimedia/epic/2013EnvIndicatorReport.html
5. Diffenbaugh, Noah, Daniel Swain and Danielle Touma. 2015. "Anthropogenic warming has increased drought risk in California". Proceedings of the

National Academy of Sciences.
http://www.pnas.org/content/early/2015/02/23/1422385112.abstract

6. Donath, Alexis. 2013. "High temperatures can bring harmful algal blooms". Minnesota Pollution Control Agency. http://www.pca.state.mn.us/index.php/about-mpca/mpca-news/current-news-releases/high-temperatures-can-bring-harmful-algal-blooms.html
7. Havens, Karl. 2015. Effects of Climate Change on the Eutrophication of Lakes and Estuaries. Univ. of Florida IFAS Extension. http://edis.ifas.ufl.edu/sg127
8. Hecky, R.E. and P. Kilham 1988. "Nutrient limitation of phytoplankton in freshwater and marine environments: A review of recent evidence on the effects of enrichment." Limnol. Oceanogr. 33(4. Part 2). 1988, 796-822.
9. Johnston, Gina and John McMurtry, 2009-2013. Lake Almanor Water Quality Reports. Plumas County Water Conservation and Flood Control District and Almanor Basin Watershed Advisory Committee.
10. Johnston, Gina and Scott McReynolds, 2015. Lake Almanor Water Quality Report, 2014. Plumas County Water Conservation and Flood Control District and Lake Almanor Watershed Advisory Group.
11. Konopkai, Allan and Thomas D Brock. 1978. "Effect of temperature on blue-green algae (Cyanobacteria) in Lake Mendota". Appl. And Env. Microbiology, Oct. 1978, p.572-576.
12. Kovner, Guy. 2013. "Warming Trend a Sign of Climate Change in Clear Lake". The Press Democrat. http://www.pressdemocrat.com/news/2214023-181/warming-trend-a-sign-of
13. Mello, Inken. 2014. "Success story: 20 years of hypolimnetic oxygenation of a reservoir". 2014. http://www.oclwa.org/pdf/2014Presentations/1_Mello-%20SUCCESS%20STORY_%2020%20Years%20of%20Hypolimnetic%20Oxygenation%20of%20a%20Reservoir.pdf
14. Mission Viejo Dispatch. 2010. "Speece Cone will fight water odor". http://missionviejodispatch.com/environment/speece-cone-will-fight-water-odor/
15. Nordstrom, D. Kirk. 2011. "Hydrogeochemical processes governing the origin, transport and fate of major and trace elements from mine wastes and mineralized rock to surface waters". Applied Geochemistry 26(2011) 1777-1791.
16. Oregon Climate Change Research Institute. 2013. Climate Change in the Northwest: Implications for Our Landscape. http://cses.washington.edu/db/pdf/daltonetal678.pdf
17. Ruttenberg, K.C. 2003. The Global Phosphorus Cycle. Treatise on Geochemistry. Volume 8. http://adsabs.harvard.edu/abs/2003TrGeo...8..585R
18. Schneider, P., S. J. Hook, R. G. Radocinski, G. K. Corlett, G. C. Hulley, S. G. Schladow, and T. E. Steissberg. 2009. Satellite Observations Indicate Rapid Warming Trend for Lakes in California and Nevada. Geophysical Research Letters. Volume 36. (L22402, doi:10.1029/2009GL0040846.)
19. Scripps Inst. Of Oceanography. 2013. Scripps Researchers Assess the Future of Climate in California. https://scripps.ucsd.edu/news/8155

20. Stetson Engineers and Pacific Gas and Electric Company. 2007a. 2006 North Fork Feather River Special Testing Report. March 2007. Prepared for the State Water Resources Control Board. 87 pp
21. Stetson Engineers, Inc. 2009. Level 3 Report: Analysis of Temperature Control Alternatives Advanced from Level 2 Designed to Meet Water Quality Requirements and Protect Cold Freshwater Habitat along the North Fork Feather River. Prepared for the State Water Resources Control Board. Stetson Engineers, Inc., San Rafael, California. September.
22. US EPA. 2015. Climate Change and Harmful Algal Blooms. http://www2.epa.gov/nutrientpollution/climate-change-and-harmful-algal-blooms
22. Valentine, Katie. 2015. Unseasonal toxic algae bloom in California kills three dogs. http://thinkprogress.org/climate/2015/02/02/3617937/california-algae-bloom/

CURRICULUM VITAE: Updated March 2015

KAROLYN R. (GINA) JOHNSTON

Academic History

Bachelor of Science Degree - University of Florida, 1967
Major: Zoology
Minor: Chemistry

Doctor of Philosophy - University of Florida, 1970
Major: Limnology
Minor: Environmental Engineering

Employment History

1. January, 1971-August, 1977 - Assistant Professor, Department of Geology and Physical Sciences, California State University, Chico. Tenured-August,1976.
2. September, 1977-August, 1982 - Associate Professor, Department of Geology and Physical Sciences, CSU, Chico.
3. 1982-2009 - Professor, Department of Geology and Physical Sciences, CSU, Chico (now Geological and Environmental Sciences Dept.).
4. June, 1981-Aug 1987 - Chair, Department of Geology and Physical Sciences, CSU, Chico.
5. June, 1990- August, 1993 - Director, Institute for Liberal and Interdisciplinary Studies, CSU, Chico.
6. August, 1995 - August, 1998: Chair, Department of Geosciences, CSU, Chico.
7. August 2001- August 2004: Director of Liberal Studies Program, CSU, Chico
8. August 2004- August 2006: Professor, Dept. of Geological and Environmental Sciences
9. August 2006- May 2009: Chair, Dept. of Geological and Environmental Sciences
10. Retired, Professor Emerita, 2009

Publications and Presentations

1. 1970 - K. R. (Gina) Maslin. Effects of the Cross-Florida Barge Canal on Water Quality In the Oklawaha Regional Ecosystem, In Environmental Impact of the Cross-Florida Barge Canal, pg. 73-79. Florida Defenders of the Environment.
2. 1970 - K.R. (Gina) Maslin. Interactions of littoral zooplankton and their fish predators (portion of Ph.D. dissertation), In Eutrophication Factors in North Central Florida Lakes. Univ. of Fla. Ind. Eng. Exp. Sta. Bull. Ser. 134.
3. 1976 - K.R. (Gina) Huntsinger and Paul E. Maslin. Contribution of phytoplankton, periphyton, and macrophytes to primary production in Eagle Lake, California. Calif. Fish and Game 62(3):187-194.
4. 1976 - K.R. (Gina) Huntsinger and Paul E. Maslin. A limnological comparison of the three basins of Eagle Lake, California. Calif. Fish and Game 62(4):232-245.

5. 1983 - K.R. (Gina) Rothe. Defining the relationship between turbidity and precipitation in two northern California water supply reservoirs.Verh. Internat. Verein. Limnol. 22: 1456. (abstract only).
6. 1984. K.R. (Gina) Rothe. Variation in trophic state indicators in two northern California reservoirs. Calif. Fish and Game 70(2): 68-77.
7. August, 1983 - presented a paper "An Investigation of Turbidity in Two Northern California Water Supply Reservoirs" at Societas Internationalis Limnologiae, Lyon, France.
8. December, 1984 - presented "Turbidity Investigations and Watershed Management" at Environmental Protection Agency, Corvallis, OR.
9. November, 1996 - presented paper at North American Lake Management Society Symposium in Minneapolis: Effect of Varying Precipitation on Trophic State Indicators in a Northern California Water Supply Reservoir.
10. November, 1998 – presented a paper at North American Lake Management Society Symposium in Banff, Canada: Changes in Phytoplankton, Zooplankton, and Nutrients In a Water Supply Reservoir as a Result of Drawdown.
11. November, 2008 – presented a paper at the North American Lake Management Society Symposium in Lake Louise, Canada: Long-term Effects of Varying Precipitation on Trophic State Indicators in a Northern California Water Supply Reservoir". Co-author: John McMurtry.

Recent Awards and Contracts:

1. November, 1989 - awarded $4,945 CSU Research Award for project, "Investigation of the Bioaccumulation of Lead from Ammunition in Horseshoe Lake".
2. August, 1990 - $17,691 from National Science Foundation for purchase of gas chromatograph. Matching funds provided by CSU, Chico.
3. March, 1991 - awarded $4,911 from College of Natural Sciences to buy flame ionization detector, supplies and chemicals for preliminary studies with gas chromatograph.
4. May, 1991 - awarded $3,500 Summer Fellowship for research on pesticides in ground water of Butte and Glenn counties.
5. August, 1992 - awarded $4799 from Auxiliary Revenue Distribution Funds to support graduate student/faculty environmental research.
6. May, 1994 - awarded $9652 from Auxiliary Revenue Distribution Funds to purchase environmental science equipment
7. June, 1996 - awarded $46,633 from NSF to purchase equipment for Environmental Lab. $54,000 matching funds provided by CSU, Chico.
8. December, 1997 - awarded $5959 contract from Nature Conservancy to conduct water quality monitoring at Vina Plains Preserve (with Dave Brown).
9. May, 1998 - awarded $7708 contract from Paradise Irrigation District to conduct water quality monitoring at Paradise and Magalia Reservoirs.
10. April – May 2000: awarded a contract ($1275) from Shasta Vineyards Homeowners Association in Redding, CA to perform a water quality evaluation of their lakes. A report was submitted in May 2000.
11. May - August 2000: awarded a contract from Paradise Irrigation District ($7708), for limnological investigation of their water supply reservoirs.

12. April-June 2002: awarded contract from Paradise Irrigation District ($7735), for limnological investigation of their water supply reservoirs.
13. April 2005: awarded contract from Paradise Irrigation District ($10, 532) for limnological investigation of water supply reservoirs.
14. March 2008: awarded contract from Paradise Irrigation District ($14,498) for limnological investigation of water supply reservoirs. Co-PI: John McMurtry.
15. March 2009: awarded contract from Almanor Basin Watershed Advisory Committee ($16,126) for limnological investigation of water quality in Lake Almanor. Co-PI: John McMurtry

15. March 2010: awarded contract from Almanor Basin Watershed Advisory Committee ($13,000) for limnological investigation of water quality in Lake Almanor. Co-PI: John McMurtry
16. March 2011: awarded contract from Almanor Basin Watershed Advisory Committee ($11,500) for limnological investigation of water quality in Lake Almanor. Co-PI: John McMurtry
17. April 2012: awarded contract from Almanor Basin Watershed Advisory Committee ($13,316) for limnological investigation of water quality in Lake Almanor. Co-PI: John McMurtry
18. April 2013: awarded contract from Almanor Basin Watershed Advisory Committee ($14,000) for limnological investigation of water quality in Lake Almanor. Co-PI: John McMurtry
19. April 2014: awarded contract in conjunction with Scott McReynolds, DWR, from LAWG for limnological investigation of water quality in Lake Almanor.

Other Professional Activities

1. Consultant to Paradise Irrigation District, 1974-2008.
2. Consultant to community group, P.O.W. (Protect Our Watershed), 1991-1997
3. Judge, Butte County - Chico Science Fair (every year since 1974)
4. May, 1997 - attended NSF Chautauqua Workshop on Interdisciplinary Science Education.
5. December, 1997-attended two workshops: Advanced Algal Identification and Rapid Bioassessment Protocols
6. March 1999 –attended a 3-day worshop in Milwaukee, WI, sponsored by Lachat Instruments. I became familiar with the operation of the Lachat ion analyzer and have assisted several students in water analysis projects
7. April – May, 1999 - served as a peer reviewer for the California Regional Water Quality Control Board-Lahonton Region Draft Basin Plan for Indian Creek Reservoir.
8. Member, Certification Board of North American Lake Management Society, 1989-2010.
9. Certified Lake Manager award from North American Lake Management Society: Fall, 1993 and renewed in 2001. This required review of professional record.
10. Chapter reviews for Environmental Science texts: at least one per year, 1996-2006
11. Consultant to Almanor Basin Watershed Advisory Committee since 2000.

ATTACHMENT 2

A.A. RICH AND ASSOCIATES

Alice A. Rich, Ph.D.
Principal

150 Woodside Drive
San Anselmo, CA 94960
Tel: (415) 485-2937
Fax: (415) 485-9221
alice@aarichandassociates.com
www.aarichandassociates.com

March 25, 2015

Randy Wilson
Planning Director/Co-Manager of
Flood Control and Conservation District
Plumas County Planning and Building Services
555 Main Street
Quincy, CA 95971

RE: Upper North Fork Feather River Hydroelectric Project Draft Environmental Impact/Comments on Fisheries

Dear Randy:

Attached are my comments, regarding the Upper North Fork Feather River Hydroelectric Project Draft Impact Report SCH No. 2005082112.

Thank you.

Sincerely,

Alice A. Rich, Ph.D.

Alice A. Rich, Ph.D.

Attachment

March 25, 2015

Randy Wilson
Planning Director/Co-Manager of
Flood Control and Conservation District
Plumas County Planning and Building Services
555 Main Street
Quincy, CA 95971

RE: Upper North Fork Feather River Hydroelectric Project Draft Environmental Impact/Comments on Fisheries

I. BACKGROUND

The State Water Resources Control Board (SWRCB) prepared a Draft Environmental Impact Report (DEIR) in response to Pacific Gas and Electric Company's (PG&E's) application for a water quality certification for operation of its Upper North Fork Feather River Hydroelectric Project (UNFFR Project) under a new license from the Federal Energy Regulatory Commission (FERC). The proposed project is composed of:

- Three dams that form Lake Almanor, Butt Valley reservoir, and Belden forebay, respectively;
- Five powerhouses (Butt Valley, Caribou No. 1, Caribou No. 2, Oak Flat, and Belden);
- Tunnels and penstocks connecting the reservoirs to the powerhouses; and,
- Transmission, recreation, operations and maintenance, and access facilities.

Lake Almanor is the upstream-most reservoir on the Upper North Fork Feather River (NFFR) within the proposed UNFFR Project. Butt Valley Reservoir is south of Lake Almanor on Butt Creek, a tributary to the NFFR. Belden forebay is on the NFFR downstream of Lake Almanor and below Butt Valley reservoir.

The proposed UNFFR Project is composed of the elements of PG&E's application to FERC, as well as modifications made in accordance with the 2004 Settlement Agreement (Appendix A of DEIR), mandatory conditions, and the FERC staff alternative. The SWRCB developed an array of measures that could reduce water temperatures in the NFFR below Canyon Dam. Three of the measures (thermal curtains at the Prattville intake, thermal curtains at the Caribou intakes, and increased Canyon Dam flow) were carried forward for analysis in the DEIR:

(1) Alternative 1: Installation of thermal curtains at the Prattville and Caribou Intakes and the release of up to 250 cfs to the Seneca Reach between June 15 and September 15; and,

(2) Alternative 2: Installation of thermal curtains at Prattville and Caribou Intakes.

II. OVERVIEW

This is a review of the SWRCB's DEIR, with regard to the potential impacts of PG&E's Proposed UNFFR Hydroelectric Project and Alternatives 1 and 2 on fishery resources and recreational fishing in Lake Almanor, Butt Valley Reservoir, and the NFFR, downstream of Lake Almanor. PG&E's Proposed UNFFR Project and Alternatives 1 and 2 could result in significant impacts on water quality, water temperature, and suitable (defined in the DEIR as $\leq$20°C and $\geq$5 mg/L) coldwater habitat. Those impacts, in turn, could result in significant negative effects on the fishes (rainbow and brown trout, special status fish species, and other fishes) and recreational fishing opportunities (e.g., trophy trout) in Lake Almanor, Butt Valley Reservoir, and the NFFR downstream of Lake Almanor. My comments focus on the potential effects of Alternatives 1 and 2 on the fishery resources and recreational fishing in the two reservoirs and the NFFR.

The DEIR states (page 6.5-13) that, "Impacts on fisheries would be significant if the Proposed UNFFR Project, Alternative 1, or Alternative 2 would:

- Substantially affect, either by take or through habitat degradation (e.g., adverse changes in flow or deterioration of water quality), a special-status fish species;
- Substantially interfere with the movement of any resident or migratory fish species;
- Cause a fish population to drop below self-sustaining levels; or
- Substantially affect native or introduced fish species, resulting in a reduction in the quality of the recreational fishery provided by Lake Almanor, Butt Valley reservoir, and the North Fork Feather River."

There is a good possibility that all of the above could be significant with implementation of Alternatives 1and 2.

The following are summarized in my comments:

(1) The DEIR failed to analyze and disclose factors that could have significant impacts on fishery resources habitat and populations;

(2) The DEIR's critical water temperature criteria may not be protective of rainbow trout in the NFFR, Lake Almanor and Butt Valley Reservoir;

(3) Existing coldwater conditions and Alternatives 1 and 2 would result in a larger decrease of suitable coldwater habitat that would last longer in Lake Almanor than was stated in the DEIR;

(4) Alternatives 1 and 2 could introduce nutrients and heavy metals into Lake Almanor and Butt Valley reservoir that, in turn, could have significant negative effects on the fishes and recreational fishing in the reservoirs, and the NFFR;

(5) The Maximum Weekly Average Temperature (MWAT) Methodology is an unvalidated hypothesis that is of questionable biological reliability and value, without site-specific data for this project;

(6) To determine the potential impacts of the Proposed UNFFR Project and Alternatives 1 and 2, additional studies and monitoring are needed;

(7) There is no evidence that the mitigation measures would result in less than significant impacts to fishery resources and recreational fishing in Lake Almanor, Butt Valley Reservoir, and the NFFR; and,

(8) An alternative to the mitigation of re-planting trout that is offered in the DEIR is provided: the use of a Speece Cone, or some other oxygenation infrastructure.

II. COMMENTS

A. The DEIR omitted topics that could have significant impacts on fishery resources habitat and populations and recreational fishing opportunities

The DEIR omitted the following factors from discussion, any of which could negatively affect the fishery resources in Lake Almanor, Butt Valley Reservoir, and the NFFR:

(1) Increased water temperatures in the NFFR as a result of global climate change;
(2) Increased eutrophication in Lake Almanor as a result of global climate change;
(3) Potential detrimental change in the overall concentration of nutrients, due to mixing in the hypolimnion and lower metalimnion induced by the withdrawal of hypolimnetic water from Lake Almanor; and,
(4) Studies that would identify the factors that limit populations of fish in Lake Almanor, Butt Valley Reservoir, and the NFFR.

The omission of the above-listed topics from discussion in the DEIR could affect the DEIR's impact analyses, and conclusions of the significance of potential impacts of the Proposed UNFFR Project and Alternatives 1 and 2 on fishery resources, including the rainbow trout, and two fish species of special concern, the hardhead and the Sacramento perch. In addition, such omissions could result in a reduction in recreational fishing opportunities.

1. Increased water temperatures, as a result of climate change, could have a significant negative impact on the rainbow trout in the NFFR

A discussion of global warming was omitted from the DEIR. Global warming could increase water temperatures in the Feather River system, regardless of the Proposed UNFFR Project and its Alternatives (Dr. Gina Johnston's Comments). The DEIR did not discuss whether or not climate change was even partially responsible for higher temperatures in the NFFR downstream of Lake Almanor. Higher water temperatures in the NFFR, as a result of global warming could have a significant negative impact on the rainbow trout in the NFFR, irrespective of the Proposed UNFFR Project and Alternatives. That information needs to be analyzed to differentiate the results of higher water temperatures in the NFFR that would be due to global warming versus those due to the Proposed UNFFR Project and it Alternatives.

Furthermore, given the long-term time horizon (e.g., 30-50 years) of the proposed FERC license and 401 certification, climate change and its potential to warm baseline temperatures and reduce the availability of suitable coldwater habitat in summer/fall months to critical levels needs to be addressed. To accurately analyze and disclose all of the potential effects of Alternatives 1 and 2 over the life of the project, the DEIR must assess the impacts of the Alternatives removing coldwater habitat in the context of warmer, climate-change affected Lake Almanor.

2. Increased eutrophication, as a result of increased temperatures due to climate change, could result in significant negative impacts on Lake Almanor

Global warming could lead to eutrophication, including increased algal growth in Lake Almanor. Data collected from 2010-2014 demonstrated that algal populations have been increasing in Lake Almanor (Johnston and McMurtry, 2012-2015, 2010). Large populations of blue-green algae in August and September are already a concern (Comments of Dr. Gina Johnston, Plumas County Comments).

Increased eutrophication could result in the following impacts on the trout (and other fish species) in Lake Almanor:

- Blue-green algae (cyanobacteria) can be toxic to fishes, similar to its effects on humans; and,
- Decreased dissolved oxygen (DO) concentrations could negatively affect, or even kill, the trout and other fishes.

The toxins produced by the blue-green algae include neurotoxins and hepatoxins (Codd et al., 1989; Carmichael, 1992). Chronic exposure of fish (including salmonids) to toxic cyanobacterial blooms resulted in death, ionic imbalance and reduced growth, gill function inhibition, and digestive organ disorders (Huynh-Delerme et al., 2005; Bury et al., 1995; Gaete et al., 1994; Beveridge et al., 1993; Rabergh et al., 1991; Sugaya et al., 1990).

When algae die, they decompose and the nutrients contained in that organic matter are converted into inorganic form by microorganisms. This decomposition process consumes oxygen that, in turn, reduces the concentration of DO. The depleted DO levels might lead to fish kills (www.cdph.ca.gov), sublethal chronic effects on fishes, and a range of other effects, including reducing biodiversity.

Fish kills, as a result of blue-green algae blooms, often occur in California and are listed on the California Department of Public Health's web site (www.cdph.ca.gov), as algae is a health hazard to humans and other animals. To accurately analyze and disclose all the potential effects of Alternatives 1 and 2 over the life of the project, the DEIR must assess the impacts of the Alternatives in removing available coldwater habitat in the context of a warmer, climate-change-affected Lake Almanor.

3. Nutrient changes could result in negative effects on fishes in Lake Almanor

The proposed UNFFR Project may cause a detrimental change in the overall concentrations of nutrients, due to mixing in the hypolimnetic and lower metalimnion, induced by the withdrawal of hypolimnetic water from Lake Almanor (Dr. Gina Johnston's Comments). The mixing in the hypolimnion could increase the amount of nutrients available to algae at a time when sunlight and warmer water temperatures would be ideal for growth. Increased nutrients would increase algae growth. The potential negative effects of the increased algae on trout (and other fish species) in Lake Almanor are discussed in the previous section above.

4. Studies that would identify the factors that limit populations of fish in Lake Almanor, Butt Valley Reservoir, and the NFFR

To quantify potential impacts of the Proposed UNFFR Project and its Alternatives on the fish in Lake Almanor, Butt Valley Reservoir, and the NFFR, studies are needed to identify factors that are currently limiting populations of the fish in those waterbodies.

Food Availability

The importance of food availability in determining protective water temperatures in Lake Almanor, Butt Valley Reservoir, and the NFFR cannot be overemphasized. In both the laboratory and in the wild, trout growth varies as a joint function of ration and water temperature (Bjornn, 1971;Filbert and Hawkins, 1995). In general, the effect of food quantity on growth is greatest at optimum temperatures. And, the effect of varying temperature is small, under conditions of low food supply. The effect of varying temperature increases, as the amount of food available to individual fish increases.

Food limitations commonly cause reductions in summer growth in rainbow trout (Cada et al., 1987; Preall and Ringler, 1989). If food becomes limited in the field, the maximum temperature at which growth is positive declines and the optimum growth zone shifts to lower temperatures to compensate for the elevated respiration/growth ratios (Elliott, 1981). The amount of food available to the trout in Lake Almanor, Butt Valley Reservoir, and the NFFR is unknown. To determine whether or not the Proposed UNFFR Project and its Alternatives would affect the trout's ability to feed and assimilate that food under the varying thermal conditions, studies of food availability/ingestion/assimilation, as a function of water temperature, need to be conducted.

Affect of current trout stocking practices on the trout fishery

The effectiveness of the current stocking of trout in Lake Almanor is unknown. Although California Department of Fish and Wildlife plants thousands of trout each year, and the Fisherman's Association raises trout in pens and releases them into the lake each year, there are no current data that demonstrate how effective these stocking practices are. As reported in Table 6.6-2 in the DEIR (page 6.6-7), from 2001-2011, there have been varying quantities and sizes (ages) of trout and Chinook salmon planted in Lake Almanor. No recent angler creek surveys have been conducted, nor has anyone determined the relative success of each year of planting. To determine the relative success of the current stocking program in Lake Almanor, ongoing angler creel census monitoring is warranted. Without such data, it is not possible to determine whether or not the mitigation measure to plant trout would be effective and result in reducing the impacts of the proposed UNFFR Project and Alternatives to less than significant.

Affect of the thermal refugia areas on survival of rainbow trout in Lake Almanor

Persons knowledegable about the fishery resources (including fishing guides in the area) that I spoke with, told me that the springs around Lake Almanor offer a thermal refuge for the trout during the summer months (Maumoynier, 2015; Jemenez, 2015; Kossow, 2015). The trout appear to leave Lake Almanor to avoid the unsuitable habitat conditions (increased water temperatures and decreased DO concentrations) and move to the springs. The trout leaving the lake for cooler waters in the spring often have parasitic copepods in their gills, the presence of which is a typical stress reaction as a result of thermal or other stress. In addition, Lake Almanor has large underwater springs. The DEIR (page 6.6-5) states that:

> *"Lake Almanor's large underwater springs have also been anecdotally reported to be localities where trout and salmon may congregate during the summer, when coldwater is limited. However, it is not known what portion of the lake's coldwater fish population may use these spring areas as a thermal refuge."*

Information about such thermal refugia areas is critical to the management of the impacts of the Proposed UNFFR Project and Alternatives and could provide the SWRCB with additional mitigation opportunities.

B. The DEIR's critical temperature criteria may not be protective of the rainbow trout in the NFFR, Lake Almanor, or Butt Valley Reservoir

Of all environmental factors that affect fish, water temperature is considered to be the ecological master factor (Brett, 1971). Thus, it is of paramount importance to determine thermal criteria that would protect the rainbow trout in the NFFR, Lake Almanor, and Butt Valley Reservoir.

To determine protective water temperatures for rainbow trout under the conditions of the Proposed UNFFR Project and its Alternatives is no small task. Water temperature requirements for rainbow trout are dependent on a variety of factors, including, but not limited to: (1) previous temperatures that the fish have been exposed to; (2) food availability; (3) environmental stressors (e.g., diseases, pollution; (4) fish size and age; and, (5) photoperiod (McCauley et al., 1977; Filbert and Hawkins, 1995; Dockray et al., 1996; Kwain and McCauley, 1978; Evans et al., 1962). Thus, one cannot determine water temperature requirements and, from there, impacts from the Proposed UNFFR Project and its Alternatives, on rainbow trout, without carefully analyzing the existing information on thermal requirements of rainbow trout and identifying any data gaps that exist. Such an analysis would aid in determining the water temperatures that would be protective of the rainbow trout under the conditions of the Proposed UNFFR Project and Alternatives 1 and 2.

Similar to all specific areas of scientific inquiry, fish thermal physiology has its own nomenclature that can be confusing when there are different meanings for "optimal", "lethal", "preferred", "tolerance", "threshold", and "stressful" temperatures. Such a lack of standardization is problematical when one is attempting to determine the temperatures that would be protective for rainbow trout under the conditions of the Proposed UNFFR and Alternatives. It is extremely important that the information contained in existing scientific literature not be misinterpreted. It is also of utmost importance that, when trying to find scientific support for thermal protection for rainbow trout, information not be "cherry picked" out of specific publications, as that would present an incomplete picture of both thermal requirements and potential impacts on the rainbow trout.

A variety of thermal studies has been undertaken on the various life stages of rainbow trout over the decades. When one examines the results of the thermal studies, the following general conclusions can be made about fish in general and rainbow trout, specifically:

- The physiological and behavioral responses of water temperature to fish, including trout, are site-specific;

- Water temperature requirements are directly dependent upon the availability of food;

- Fish do not feed maximally in the wild. Thus, one cannot directly apply the results of laboratory data when fish are fed maximal rations, to a field environment;

- Rarely, and only under very controlled conditions, can one use data from a laboratory study and apply those data to a field situation with any level of confidence;

- Water temperatures that are considered optimal for fish in a laboratory environment, where the fish are fed all they can eat, will always be higher than those for fish in a creek or river or lake. If site-specific data are not available, and one is relying on existing scientific studies, in an attempt to determine protective water temperatures, the laboratory results need to be adjusted downward to account for the influences of reduced food availability, competition, predation, and other environmental variables. Growth rates have been observed in the field that are less than those predicted in the laboratory under maximum feeding (Preall and Ringler 1989; Cada et al., 1987);

- To determine the optimal water temperatures for any species of fish, one needs to know how efficient the food eaten is being converted to "fish flesh" at each temperature studied. This process is called "food conversion efficiency". It is not enough to measure growth rate alone in a laboratory environment and directly apply those results to fish in the wild because, as water temperatures increase, it takes more and more food for the fish to grow. And, in a laboratory environment, one can keep feeding the fish. But, in the natural environment, if the fish does not obtain adequate food at the higher temperatures then it will not grow; and,

- Due to the variation that exists in the results of thermal studies for rainbow trout, one should always err on the side of caution and provide a margin of safety.

Different results occur for different types of studies. Laboratory studies allow manipulation of factors that control and limit a fish's response to water temperature. Cause-and-effect relationships can be derived from such manipulations. In the natural environment, it is much more difficult to determine protective water temperatures for rainbow trout and other fishes, due to the myriad of factors that can affect the outcome. Thus, in the absence of field studies, to determine protective water temperatures, the information from the laboratory studies must be interpreted correctly, whether it be information that is physiological (e.g., growth, food conversion efficiency), behavioral (e.g, preference) or lethal.

The DEIR states that,

> "*Key temperature thresholds above which some level of physiological impairment can occur are generally found to occur over a temperature range of from 18°C to 21°C for rainbow trout for chronic exposures, typically measured as the daily temperature over a time frame of one week or more (Hokanson et al 1977, Wurtsbaugh and Davis 1977, Bell 1990, McCullough 1999, Myrick and Cech 2000, Sullivan et al 2000, McCullough et al. 2001).*" (DEIR page 6.6-2)

It is not clear to me how the DEIR reached its conclusion that, "Key temperature thresholds above which some level of physiological impairment can occur.... (is) from 18° C to 21° C for rainbow trout.....". The studies cited in the DEIR do not support the DEIR's conclusion and there are no site-specific studies to support this conclusion. Please indicate where in the DEIR this conclusion is supported.

Regarding the citations above that, purportedly, provide scientific foundation for the DEIR's "Key temperature thresholds..." , the following is a list that summarizes each of the researcher's conclusions in those studies, which demonstrate that these studies do not support the DEIR's "Key temperature thresholds...":

- Hokanson et al. (1977), in a laboratory study with juvenile rainbow trout fed maximal rations all day, did not study conversion efficiency of the food consumed. Therefore, the optimal water temperature (s) could not be ascertained from that study.

- Wurtsbaugh and Davis (1977) studied juvenile anadromous steelhead, instead of the resident rainbow trout. Steelhead are known to have much lower thermal requirements than resident rainbow trout. As there are no steelhead anymore in the NFFR, it is not clear how that study supported the DEIR's conclusion, regarding thermal range at which there will be no physiological impairment to the rainbow trout.

- After summarizing many of the studies that have been conducted on rainbow trout, McCullough et al. (2001) concluded that, because thermal criteria must protect both adult and juvenile forms of rainbow trout, an optimal regime appeared to most consistently occur in the range of 13-15 °C. This range is considerably lower than the one reported in the DEIR and yet this publication was cited in support of the DEIR's thermal thresholds.

- Myrick and Cech (2000)[1], who used fish fed to satiation and measured food conversion efficiency, concluded that 14-19 °C was the optimal growth temperature for both the strains ("Eagle Lake" and "Mt. Shasta") of rainbow trout. This is a wider, but lower upper protective temperature, thermal range than the DEIR's 18-21°C.

- Bell (1990) used data from previous studies and depicted them on a figure labeled "E Sportfish-Optimum Range". On that figure, the range under rainbow trout was 12.2-18.9 C. Again, the lower part of this range is considerably lower than the range in the DEIR purported to be protective of rainbow trout.

- In the Sullivan et al. (2000) report, water temperature studies that had been conducted on salmonids were summarized, but the only information on rainbow trout related to lethal temperatures. In that report the studies focused on lethal temperatures, effects of growth on temperatures, and bioenergetics modeling, but the focus, except for the lethal temperatures, did not include rainbow trout. Instead, the effects of temperatures on steelhead were discussed. Steelhead are known to have much lower thermal requirements than rainbow trout (Rich, 1987). Thus, the Sullivan et al. (2000) report does not appear to be relevant for determining protective water temperatures for rainbow trout for the UNFFR Project and its Alternatives.

In addition, a laboratory study (Myrick and Cech, 2000) was cited in Appendix F of the DEIR, presumably, as scientific support for the DEIR's 18-21° C range. The study focused on two California strains of rainbow trout ("Eagle Lake" and "Mt. Shasta"), as discussed in the previous paragraph. And, the optimal thermal range for growth for the rainbow trout reported in that study was 14-19 °C, which is not a scientifically-based reason to choose the 18-21°C "protective" range reported in the DEIR.

In the discussion of the field study (Matthews et al., 1994) in Appendix F of the DEIR, the authors stated that "Identification of the upper end of the normative temperature range for rainbow trout is further corroborated by a field study of a Sierra Nevada Stream by Matthews et al. (1994), who observed that rainbow trout spent a larger proportion of time at 19 °C (the warmest available) than at cooler temperatures (available down to 14.5 °C) in a stratified pool."

[1] Myreck and Cech (2000) were not listed in Chapter 9. References. However, I assume it is the same reference cited in Appendix F

Appendix F to the DEIR cited (page 8) this reference in support of the upper end of the "protective" 18-21° C range. The actual story behind the Matthews et al. (1994) study is more complicated than reported in Appendix F:

- The rainbow trout were found in a wide range of water temperature, 12.8-19.1 °C , whereas the range of water temperatures in the pool was 6.1-19.4 °C, depending upon whether the thermal data were collected at the bottom or surface of the pool, or the inlet to the pool. Thus, the trout were not found below 12.8 °C or above 19.1°C;

- No food availability studies were conducted, so there were no data to determine why the fish inhabited the various parts of the pool;

- The authors stated that rainbow trout might have occupied the warmer areas of the pool when they did because the cool water area was too small to accommodate all of the fish; and,

- Of the six rainbow trout that occupied the pool in the study, two were deleted from the analysis, so their results were based on only four fish, hardly a robust population sample upon which to make conclusions.

Thus, as with all of the laboratory and field studies on the effects of water temperature on rainbow trout, the actual details of, and conclusions made, in the studies were much more complicated and revealing that reported in the DEIR or Appendix F to the DEIR.

Furthermore, there have been no site-specific food availability or thermal bioenergetics studies that would demonstrate that there is enough food to sustain the different life stages of the rainbow trout in Lake Almanor, Butt Valley Reservoir, and the NFFR at temperatures between 18-21 °C. Finally, although the subject of sublethal thermal stress was discussed in Appendix F of the DEIR, a number of studies have demonstrated that temperatures within the 18-21°C range and below could result in thermal stress in rainbow trout (Taylor and Barton, 1992; McCauley and Pond, 1971; Dickson and Kramer, 1971; Kwain and McCauley, 1978; Piper et al., 1982; Sadler et al., 1986; Ferguson, 1958) and temperatures above 18 °C could inhibit long-term growth. Established indicators of thermal stress on fish include, but are not limited to (Elliott, 1981):

- reduced growth;
- reduced food conversion efficiency;
- avoidance;
- disease outbreaks;
- loss of appetite;
- hyperactivity; and,

- secretion of stress hormones such as adrenalin and cortisol.

All of these stress indicators have been directly and indirectly linked with the survival of natural populations of salmonids, including trout (Elliott, 1981). In addition, the stress impacts of chronic sublethal water temperatures on trout and other salmonids are positively correlated to the duration and severity of exposure. And, similar to humans, stress is cumulative in trout and other fishes (Barton et al. 1986; Mesa, 1994). Thus, if there are other stressors that are affecting the rainbow trout (e.g., pollution, low DO concentrations, etc.), in addition to the thermal stress, the physiological results are cumulative (i.e., the "whole is greater than the sum of the parts") and the fish can ultimately die, as a result of continued multiple stressors. And, the longer the rainbow trout is exposed to thermal stress and other stressors, the less likely it is to survive long-term. Any action, including the Proposed UNFFR Project and Alternatives. that promote stressful thermal conditions would reduce the chances for survival of the rainbow trout in Lake Almanor, Butt Valley Reservoir, and in the NFFR.

Water temperature affects all life stages of the rainbow trout and identifying protective ranges for each of the life stages of this species is complicated. "Cherry picking" specific facts out of studies, while ignoring other relevant facts and information requirements, is not a correct method for determining the temperatures that would be protective of rainbow trout under the Proposed UNFFR Project and its Alternatives. Thus, as there are no site-specific temperature studies (including food availability studies) that identify protective water temperatures for rainbow trout in Lake Almanor, Butt Valley Reservoir, and the NFFR, such studies are warranted before the SWRCB can determine the potential impacts on rainbow trout, and accurately present them in the DEIR.

C. Existing coldwater conditions and coldwater impacts under the Proposed UNFFR Project on the fishery resources in Lake Almanor are greater than stated in the DEIR

Existing coldwater conditions and conditions under the Proposed UNFFR in Lake Almanor are worse than stated in the DEIR (Dr. Gina Johnston, Plumas County Comments). As such, the DEIR's analysis needs to be corrected to disclose and account for the worse conditions, as the Proposed UNFFR Project would have a greater impact on the fish in Lake Almanor

D. Impacts of Alternatives 1 and 2 on the fishery resources in Lake Almanor, Butt Reservoir, and the NFFR

1. Alternatives 1 and 2 would result in a larger decrease of suitable coldwater habitat that would last longer in Lake Almanor than was stated in the DEIR

The DEIR's conclusion that the reduction of coldwater habitat would be small and of short duration in a normal water year, as a result of operation of the thermal curtains at Lake Almanor (Alternative 1), was incorrect (Dr. Gina Johnston Comments). In fact, in a normal water year there would be more than a 20% reduction in suitable habitat and it would last through September.

This DEIR's analysis needs to be corrected to disclose and account for this substantially larger impact and its longer duration. Lengthening the period of time during which fish in the lake are exposed to unsuitable conditions with limited refugia would obviously have a greater impact on the rainbow trout in Lake Almanor than was reported in the DEIR.

2. **Alternatives 1 and 2 could introduce nutrients and heavy metals into Lake Almanor and Butt Valley Reservoir that, in turn, could have negative effects on the fishes in these reservoirs, and the NFFR**

This topic was not discussed in the DEIR but should have been, as it could affect water quality and the fishes in Lake Almanor. In order to maximize the operation of the thermal curtains (Alternative 1), water must be drawn from as deep as possible. The result of this is to increase the likelihood of mixing the hypolimnion and the introduction of nutrients and trace metals into the thermocline and possibly the epilimnion. This could result in algal blooms, since nutrients would be available to the algae (Dr. Gina Johnston's Comments). In addition, the water that is discarged to the NFFR will be devoid of oxygen, and contain heavy metals, and nitrogen and phosphorous compounds. As Butt Valley Reservoir will receive hypolimnetic water from Lake Almanor, this water would also be devoid of oxygen and have elevated levels of several trace metals, along with nitrogen and phosphorous compounds. Since the reservoir is shallow and poorly stratified, mixing could occur as the water leaves the Butt Valley powerhouse and deliver additional nutrients to the algae downstream. The potential impacts of algae blooms was discussed earlier in these comments.

Although the DEIR stated (page 6.5-6) that, except for the cadmium (Lake Almanor and Butt Valley Reservoir) and iron (Lake Almanor), trace metal concentrations for Lake Almanor and Butt Valley Reservoir fell within applicable criteria, that conclusion was based on data collected from 2000-2003. The results of more recent data (Johnston and McReynolds, 2015) than those that are analyzed in the DEIR demonstrated elevated concentrations of aluminum, arsenic, copper, iron, manganese, mercury and zinc in the hypolimnion near Canyon Dam.

All of the above-listed heavy metals can be toxic, either lethal or sublethal, to fishes, including rainbow trout and other fishes that inhabit Lake Almanor and Butt Valley Reservoir (Rammoorthy and Baddaloo 1995; Taylor, 1996; Sorenson, 2000). To determine whether or not any of the heavy metals, as a result of Alternatives 1 and 2, would negatively impact the trout in the Lake Almanor, NFFR or Butt Valley Reservoir, further study/analysis is warranted. Future water quality monitoring should include heavy metal analysis for sampling sites in Lake Almanor, Butt Valley Reservoir, and the NFFR.

E. The Maximum Weekly Average Temperature (MWAT) Methodology is an unvalidated hypothesis that is of questionable reliable value without site-specific data for this project

Contrary to the statement on page 10 of Appendix F, that the MWAT was an established methodology, in fact, it is not. It is an unvalidated hypothesis. And, for the rainbow trout in Lake Almanor, Butt Valley, and the NFFR, the use of the MWAT method, as it was applied in Appendix F, is suspect. The original objective of the MWAT was to provide thermal thresholds that were safe, as well as productive, for each life stage of a given fish species (Brungs and Jones, 1977). However, as it was applied in Appendix F, it does not achieve that objective.

The MWAT method, or hypothesis, has never been rigorously validated in the field. There are many examples that demonstrate how the use of the results of one study on the same species and life stage compared to those of another study can change the results of the MWAT significantly. One example concerns the optimal temperature range for rearing coho salmon. In the report that introduced the MWAT to other government agencies, Brungs and Jones (1977) used 5-17 °C as an optimal thermal range, depending upon the season, with 15 °C being optimal in laboratory fish fed maximal rations. The upper lethal temperatures that they used ranged from 23-25° C. If one uses those optimal and lethal thermal ranges in the MWAT equation, the MWAT ranges between 11-19.7 °C for coho salmon. The NMFS and USFWS (1997) Matrix uses an "optimum" temperature of 13.2 °C and a range of upper lethal temperatures of between 24-25.8 °C for late summer rearing coho salmon. If one uses these optimal and lethal ranges in the MWAT equation, the MWAT ranges between 16.8-17.4 °C. Thus, there were two entirely different MWAT outcomes, depending upon what studies the agencies had selected to use in the MWAT model.

And, to make things more complicated, when one applies the MWAT model to a real life situation, the model may not work at all. After the 1980 Mt. St. Helens eruption, juvenile coho salmon were collected in streams where water temperatures exceeded 20 °C during much of the summer months. Despite the apparently unfavorable environment, both growth and survival rates were higher during these months than during those times when water temperatures were considered to be unstressful (i.e., below 15.6 °C). And, the long-term (i.e., 3-6 years post-eruption) consequences of the elevated water temperatures demonstrated a high productivity at these (theoretically) stressfully high water temperatures (Bisson et al. 1985). Thus, if we were to use the MWAT equation, with the data reported in the Brungs and Jones (1977) report, for the Mt. St. Helens coho salmon, one would conclude that the temperatures that would enable juvenile coho salmon to thrive should never exceed 19.7 °C. And, we would be wrong. Again, this is proof of the need for site-specific data when one wants to determine protective or optimal or preferred water temperatures for any fish species, including rainbow trout.

The temperatures used in the MWAT analysis in Appendix F were "guesstimates", based on their selection of 18-19 °C as the "optimal growth temperature" for juvenile rainbow trout that yielded an MWAT of 20.6 °C. It was this calculation that led them to select 20 °C for the mean daily temperature criterion used in all of the water temperature modeling conducted for this project. The problems with their use of the MWAT are multiple.

For example, the "optimal growth temperature" of 18-19 °C did not reflect the results of the study they cited (Myrick and Cech, 2000). Those researchers concluded that the optimal growth temperature for juvenile rainbow trout, fed maximal rations in a laboratory setting, was from 14-19 °C. Had they used the results of that study, instead of the range of 18-19 °C, in the MWAT equation, it would have yielded an entirely different MWAT, or "protective" temperature.

Also, in Appendix F, they chose a "one size fits" all approach and, by doing so, assumed that the "optimal growth temperature" was the same for juvenile rainbow trout as it was for adults. And, they assumed it was the same for the NFFR as it was for Lake Almanor and Butt Valley Reservoir. Food conditions and requirements for the rainbow trout in the NFFR are different than those in Lake Almanor Lake and Butt Valley Reservoir (Moyle, 2002). Thus, the thermal requirements may be different for the rainbow trout in the reservoirs than they are in the NFFR.

For the MWAT evaluation, the information must be available for a specific life stage and place (Armour, 1991). There are many studies that demonstrated that as trout mature, including rainbow trout, their optimal and preferred water temperatures decrease. Thus, the 20 °C that was used as the "protective" MWAT in Appendix F (and for all of the thermal modelling analysis) would probably not apply to the adult rainbow trout in Lake Almanor, Butt Valley Reservoir and the NFFR. Furthermore, as discussed on pages 7-9, the studies that were cited in support of the 18-21 °C "key threshold", did not provide scientific evidence in support of those range of temperatures chosen in Appendix F.

Finally, there isn't a fish anywhere that depends upon one temperature all the time. To choose 20 °C as temperature upon which all the temperature modelling is based, as was done in Appendix F, is short-sighted, at best. As trout and other fish live their days, water temperatures and food supplies change. With those changes, as well as others, their optimal water temperature changes. And, thus, the temperatures that are protective of the species for a specific life stage will also change. Fish are no more static than human beings. To model them as if they were static is to create a model that does not reflect their reality.

In summary, if MWAT is to be used, and I do not recommend it, at the least site-specific thermal bioenergetics studies and thermal preference studies should be conducted that would provide useful data for determining protective temperatures to use in the analysis of impacts of the Proposed NFFR Project and Alternatives 1 and 2.

F. No evidence that the Mitigation Measures would result in the less than significant impacts to fishery and other aquatic resources in Lake Almanor, Butt Valley Reservoir, and the NFFR

It is not clear to me how Mitigation Measures FS-2 through FS-5 and WQ-1 identified in the DEIR (pages 6.6-13 to 6.6-26) would result in a less than significant level for the following reasons.

(1) There are no site-specific water temperature studies that identify protective water temperatures for rainbow trout in Lake Almanor, Butt Valley Reservoir, and the NFFR

As discussed previously, the studies cited in the DEIR do not support the DEIR's conclusion that:

> *"Key temperature thresholds above which some level of physiological impairment can occur are generally found to occur over a temperature range of from 18 °C to 21 °C for rainbow trout for chronic exposures (DEIR, pages 6.6-2 to 6.6-3)... "*

Thus, before determining thermal impacts, let alone mitigation measures, of the Proposed UNFFR Projects and Alternatives 1 and 2 on the rainbow trout in Lake Almanor, Butt Valley Reservoir, and the NFFR, site-specific studies are required. Examples of the types of studies that should be conducted include: (1) site-specific thermal bioenergetics and thermal preference studies; (2) food availability studies; and, (3) water temperature monitoring at selected sites (e.g., "thermal refugia") in the reservoirs and springs, and in the NFFR.

And, before mitigation measures can be selected to reduce the potential impacts of the Proposed UNFFR and its Alternatives on the rainbow trout in Lake Almanor, Butt Valley Reservoir, and the NFFR to less than significant levels, the results of the above-listed studies need to identify protective water temperatures for the rainbow trout that provides a trophy trout fishery in the proposed project area.

(2) The DEIR provides no evidence that reduction of entrainment of the wakasagi in the Prattville intake, as a result of the installation of a thermal curtain at the Prattville intake in Lake Almanor, would not impact the Butt Valley Reservoir fishery

Wakasagi (Japanese pond smelt) is an extremely important forage fish for trout in Lake Almanor, Butt Valley Reservoir, and the NFFR Wakasagi were introduced in the early 1970's to provide an important forage base for fish-eating (e.g., trout, bass) fish in Lake Almanor (DEIR, page 6.6-6). Wakasagi are reported to reproduce in the Butt Valley powerhouse tailrace and at the mouth of Butt Creek (DEIR, page 6.6-8). The trophy trout fishery that occurs in Butt Valley Reservoir is attributed to the prey based provided by the wakasagi that have been entrained from

Lake Almanor and discharged into Butt Valley reservoir at the Butt Valley powerhouse (DEIR, pages 6.6-6 to 6.6-8).

Installation of a thermal curtain at the Prattville intake in Lake Almanor could reduce the entrainment of wakasagi, thereby reducing it transport to and abundance in, Butt Valley Reservoir (DEIR, page 6.6-25). Large numbers of wakasagi currently become entrained at the Prattville intake and are conveyed by the Butt Valley tunnel to the Butt Valley powerhouse tailrace. A reduction in entrainment, as a result of installation of the thermal curtain, would reduce the prey base in Butt Valley Reservoir for trophy trout (DEIR, page 6.6-25).

The DEIR provides no evidence that that there would be a significant decrease in wakasagi entrainment at the Prattville intake, nor does it provide any evidence that such a decrease would not impact the Butt Valley Reservoir fishery. In fact, as stated in the DEIR (page 6.6-26):

"Documents reviewed as part of the relicensing report do not provide adequate evidence neither against Gast's hypothesis concerning the potential for a significant change in wakasagi entrainment at the Prattville intake or its impact on the Butt Valley Reservoir fishery."

The DEIR does not provide a mitigation measure that would reduce the potential impact of the decrease in wakasagi on the trophy trout fishery in Butt Valley Reservoir to less than significant. Instead, the DEIR states (DEIR, page 6.6-26) that:

> *"It is probably that wakasagi have established self-sustaining populations in Butt Valley reservoir and any reduction in wakasagi entrainment at the Prattville intake as a result of the thermal curtain is not expected to have a significant effect on the presence of a suitable forage fish in the reservoir. This impact would therefore by less than significant."*

Without focused studies on the effects of the decreased entrainment of the wakasagi, as a result of the installation of the thermal curtain at the Prattville intake at Lake Almanor, there is no way to determine whether or not such a decrease in the wakasagi would result in a "less than significant" impact on the trophy trout fishery in Butt Valley Reservoir.

(3) There is no evidence contained in the DEIR that the fish mitigation measure of re-stocking trout (Mitigation Measure WQ-1, DEIR, page 6.6-20) would mitigate for the impacts resulting from the Proposed UNFFR Project and Alternatives

The idea that re-stocking trout would serve as a mitigation measure for the impacts of the Proposed UNFFR Project and Alternatives is ill-conceived for the following reasons. Due to the lack of ongoing monitoring (e.g., focused cause-and-effect monitoring, angler creel census), there is currently no evidence that planting trout in the reservoirs has been successful. Hence, there is no evidence that re-stocking trout would mitigate for the impacts resulting from the Proposed UNFFR Project and Alternatives.

Furthermore, if there were a trophy trout die-off, as a result of the Proposed UNFFR Project and Alternatives, there would be a long period where there would be no trophy trout in the reservoirs. Fishermen consider a trophy trout to be from 5 pounds or larger, which could be a trout from 3 to 7 years old (Maumoynier, 2015; Kossow, 2015). Thus, after such a die-off and re-planting, there would be many years (3-7) where there would be no trophy trout fishery because CDFW only plant "catchable-sized" (8-12", 1.5 years old) (Maumoynier, 2015) and fingerlings (young-of-the year) trout. Thus, the mitigation to re-plant trout could actually result in a very significant impact on recreational fishing for the fisherman who have fished for trophy trout in Lake Almanor for decades.

G. Use of a Speece Cone or some other similar infrastructure would provide new summer trout habitat in Lake Almanor

Part of the limitation in coldwater habitat in Lake Almanor stems, not only from the lack of cold water, but also from the fact that, at the deeper depths, the hypolimnion, the existing coldwater has limited or no DO concentration. The resulting habitat is not suitable as coldwater fish habitat. As a mitigation measure that could be far superior to re-planting trout, the installation of the Speece Cone (Dr. Gina Johnston's Comments) would provide new summer trout habitat. Thus, although water temperatures in the epilimnion would only get worse under the Proposed UNFFR and Alternatives 1 and 2, to improve habitat for trout so that they could inhabit the hypolimnion area of the reservoir, where water temperatures would be acceptable, oxygenating the water would offer a much better alternative than them DEIR's mitigation of re-stocking the reservoir.

Oxygenation of reservoirs, or portions of reservoirs, is a proven technology. East Bay Municipal Utility District is using two forms of oxygenation technology: The Speece Cone in Camanche Reservoir (San Joaquin County) and the diffuse oxygenation system in Upper San Leandro Reservoir (Alameda County). In Lake Camanche, fishing has improved as a result of the Speece Cone distributing oxygen in the lower lake waters at the dam. The raised oxygen level draws a lot of different fish species to the area, making the dam an excellent place to fish.

Installation of a Speece Cone, or similar infrastructure, near Canyon Dam would create new summer trout habitat. Installation near Prattville would expand existing habitat, and maintain habitat viable in deeper (and, therefore, colder) water in Critically Dry years.

III. SUMMARY

The DEIR states (p 6.5-13) that, "Impacts on fisheries would be significant if the Proposed UNFFR Project, Alternative 1, or Alternative 2 would:

- Substantially affect, either by take or through habitat degradation (e.g., adverse changes in flow or deterioration of water quality), a special-status fish species;
- Substantially interfere with the movement of any resident or migratory fish species;
- Cause a fish population to drop below self-sustaining levels; or,
- Substantially affect native or introduced fish species, resulting in a reduction in the quality of the recreational fishery provided by Lake Almanor, Butt Valley reservoir, and the North Fork Feather River."

From the previous comments, I conclude that, under the Proposed UNFFR Project and Alternatives discussed in the DEIR, all of the above-listed impacts could be significant. Without filling in the omitted data and studies, identifying better mitigation measures, and re-evaluating the Proposed UNFFR Project and Alternatives and analysis, there would be significant impacts on the rainbow trout, special-status (hardhead, Sacramento perch), and the recreational fishery that could not be mitigated to a level of less than significant.

V. REFERENCES CITED

Armour, C. L. 1991. Guidance for evaluating and recommending temperature regimes to protect fish. Instream Flow Information #28. 13 pages.

Barton, B. A., C. B. Schreck, and L. A. Sigismondi. 1986. Multiple acute disturbances evoke cumulative physiological stress responses in juvenile Chinook salmon. Transactions of the American Fisheries Society 115: 245-251.

Bell, M. C. 1990. *Fisheries Handbook of Engineering Requirements and Biological Criteria.* U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon. Third Edition.

Beveridge, M. C. M., D. J. Baird, S. M. Rahmatullah, L. A. Lawton, K. A. Beattie, and G. A. Codd. 1993. Grazing rates on toxic and non-toxic strains of cyanobacteria by *Hypophthalmichthys molitrix* and *Oreochromis niloticus*. Journal of Fish Biology 43: 901-907.

Bisson, P. A., J. L. Nielson, and J. W. Ward. 1985. Experimental release of coho salmon (*Oncorhynchus kisutch*) into a stream impacted by Mount Saint Helens volcano. Proceedings of the Western Association of Fish and Wildlife Agencies. 1984: 422-435.

Bjornn, T. C. 1971. Trout and salmon movements in two Idaho streams as related to temperature, food, stream flow, cover, and population density. Transactions of the American Fisheries Society 100(3): 423-439.

Brett, J. R. 1971. Energetic responses of salmon to temperature. A study of some thermal relations in the physiology and freshwater ecology of sockeye salmon (*Oncorhynchus nerka*). American Zoologist, 11: 99-113.

Brett, J. R. 1956. Some principles in the thermal requirements of fishes. Quarterly Review Biology 31: 75-87.

Brungs, W. A. and B. R. Jones. 1977. Temperature criteria for freshwater fish: protocol procedures. U. S. Environmental Protection Agency. Environmental Research Laboratory, Duluth, Minn. EPA-600/3-77-061. 129 pages

Bury, N. R., F. B. Eddy, and G. A. Codd. 1995. The effects of cyanobacterium *Microcystis aeruginosa*, the cyanobacterial hepatotoxin microcystin-LR, and ammonia on growth rate and ionic regulation of brown trout. Journal of Fish Biology 46: 1042-1054.

Cada, G. F., J. M. Loar. And M. J. Sale. 1987. Evidence of food limitation of rainbow and brown trout in southern Appalachian soft-water streams. Transactions of the American Fisheries Society 116: 692-702

Carmichael, W. W. 1992. Cyanobacteria secondary metabolites-the cytotoxins. Journal of Applied Backteriology 72: 445-459.

Dickson, J. W. and R. H. Kramer. 1971. Factors influencing scope for activity and active standard metabolism of rainbow trout (*Salmo gairdneri*). Journal Fisheries Research Board of Canada 28: 687-596.

Dockray, J. J., S. D. Reid, and C. M. Wood. 1996. Effects of elevated summer temperatures and reduced pH on metabolism and growth of juvenile rainbow trout (Oncorhynchus mykiss) on unlimited ration. Canadian Journal of Aquatic Science 53: 2752-2763,

Elliott, J. M. 981. Some aspects of thermal stress on freshwater teleosts. Pages 209-245 *in*: Pickering, A. D. (ed). *Stress and Fish*. Academic Press, San Diego, California.

Evans, R. M., F. C. Purdie, and C. P. Hickman, Jr. 1962. The effect of temperature and photoperiod on the respiratory metabolism of rainbow trout (*Salmo gairdneri*). Canadian Journal of Zoology 40: 107-118.

Ferguson, R. G. 1958. The preferred temperatures of fish and their midsummer distribution in temperate lakes and streams. Journal of the Fisheries Research Board Canada 15: 607-624.

Filbert, R. B. and C. P. Hawkins. 1995. Variation in condition of rainbow trout in relation to food, temperature, and individual length in the Green River, Utah. Transactions of the American Fisheries Society 124: 824-835.

Gaete, V., E. Canelo, N. Lagos and F. Zambrano. 1994. Inhibitory effects of *Microcystis aeruginosa* toxin on ion pumps of the gill of freshwater fish. 1994. Toxicon 32(1): 121-127.

Hokanson, K. E. F., C. F. Keliner, and T. W. Thorslund. 1977. Effects of constant temperatures and diel temperature fluctuations on specific growth and mortality rates and yield of juvenile rainbow trout, *Salmo gairdneri*. Journal of the Fisheries Research Board of Canada 34: 639-648.

Jemenez. M. 2015. Fishing Guide, Plumas County. Phone and email communications, March 2015.

Johnston, G. and J. McReynolds. 2010. Lake Almanor Water Quality Report, 2010. Prepared for Plumas County Flood Control & Water Conservation District and Almanor Basin Watershed Advisory Committee. December 2010. 24 pages.

Johnston, G. and J. McReynolds. 2012. Lake Almanor Water Quality Report, 2011. Prepared for Plumas County Flood Control & Water Conservation District and Almanor Basin Watershed Advisory Committee. January 2012. 23 pages.

Johnston, G. and J. McReynolds. 2013. Lake Almanor Water Quality Report, 2012. Prepared for Plumas County Flood Control & Water Conservation District and Almanor Basin Watershed Advisory Committee. January 2013. 27 pages.

Johnston, G. and J. McReynolds. 2014. Lake Almanor Water Quality Report, 2013. Prepared for Plumas County Flood Control & Water Conservation District and Almanor Basin Watershed Advisory Committee. January 2014. 26 pages

Johnston, G. and J. McReynolds. 2015. Lake Almanor Water Quality Report, 2014. Prepared for Plumas County Flood Control & Water Conservation District and Almanor Basin Watershed Advisory Committee. January 2014. 26 pages. Final Draft.

Jones, J. R. E. 1964. *Fish and River pollution*. London, Butterworths. 203 pages.

Kwain, W-H and R. W. McCauley. 1978. Effects of age and overhead illumination on temperatures preferred by underyearling rainbow trout, *Salmo gairdneri*, in a vertical temperature gradient. Journal of the Fisheries Research Board of Canada 35: 1430-1433.

Kossow, M. 2015. Fisheries biologist. Phone and email communications, March, 2015.

Maumoynier, T. 2015. Fishing Guide, Plumas County. Phone and email communications, March 2015

Matthews, K. R., N. H. Berg, D. L. Azuma, and T. R. Lambert. 1994. Cool water formation and trout habitat use in a deep pool in the Sierra Nevada, California. Transactions of the American Fisheries Society 123: 549-564.

McCauley, R. W. and W. L. Pond. 1971. Temperature selection of rainbow trout (*Salmo gairdneri*) fingerlings in vertical and horizontal gradients. Journal of the Fisheries Research Board of Canada 28: 1801-1804.

McCauley, R. W., J. R. Elliott, and L. A. A. Read. 1977. Influence of acclimation temperature on preferred temperature in the rainbow trout *Salmo gairdneri*. Transactions of the American Fisheries Society 106(4): 362-365.

McCullough, D. A., S. Spalding, D. Sutdevant, and M. Hicks. 2001. Summary of technical literature examining the physiological effects of temperature on salmonids. Issue Paper 5. EPA-210-D-01-005. May 2001. 114 pages

McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. Water Resource Assessment, Columbia River inter-Tribal Fish Commission, Portland, OR. EPA-910-010. 291 pages.

Mesa, M. G. 1994. Effects of multiple acute stressors on the predator avoidance ability and physiology of juvenile Chinook salmon. Transactions of the American Fisheries Society 123: 786-793.

Moyle, P. B. 2002. *Inland Fishes of California.* University of California Press, Berkeley. 502 pages.

Myrick, C. and J. J. C ech, Jr. 2000 . Temperature influences on California rainbow trout physiological performance. Fish Physiology and Biochemistry 22: 245-254.

NMFS (National Marine Fisheries Service) and U. S. Fish and Wildlife Service. 1997. Aquatic properly functioning condition matrix. NMFS. Southwest Region, Northern California Area Office, Santa Rosa and USFWS, Arcata, California.

Piper, R. G., B. McElwain, L. E. Orme, J. P. McCraren, L. G. Fowler, and J. R. Leonard. 1982. *Fish Hatchery Management.* U. S. Department of the Interior Fisheries and Wildlife Service. Washington D.C. 517 pages.

Preall, R. J. and N. H. Ringler. 1989. Comparison of actual and potential growth rates of brown trout (*Salmon trutta*) in natural streams based on bioenergetics models. Canadian Journal of Fisheries and Aquatic Science. 46: 1067-1076.

Rabergh, C. M. I., G. Bylund, and J. E. Eriksson. 1991. Histopathological effects of microcystin-LR, a cyclic peptide toxin from the cyanobacterium (blue-green alga) *Microcystis aeruginosa,* on common carp (*Cyprinus carpio* L.). Aquatic Toxicology 20: 131-146.

Ramamoorthy, S. and E. G. Baddaloo. 1995. *Handbook of Chemical Toxicity Profiles of Biological Species.* Volume I Aquatic Species. Lewis Publishers. 386 pages.

Sadler, S. E., G. W. Friars, and P. E. Ihssen. 1986. The influence of temperature and genotype on the growth rate of hatchery-reared salmonids. Canadian Journal odd Animal Science 66: 599-606.

Sorenson, E. M. 2000. *Metal Poisoning in Fish.* CRC Press, Boca Raton. 374 pages.

Sugaya, Y. M. Yasuno, and T. Yanai. 1990. Effects of toxic *Microcystis viridis* and isolated toxins on goldfish. Japanese Journal Limnology 51(3): 149-153.

Sullivan, K., D. J. Martin, R. D. Cardwell, J. E. Toll, and S. Duke.l 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute, Portland, Oregon.

Taylor, E. W. (editor). 1996. *Toxicology of Aquatic Pollution. Physiological, Molecular and Cellular Approaches.* Society for Experimental Biology Seminar Series: 57. 283 pages.

Wixom, L. 1989. North Fork Feather River Fisheries Management Plan. California Department of Fish and Game, Environmental Services. April 1989.

Wurtsbaugh, W. A. and G. E. Davis. 1977. Effects of temperature and ration level on the growth and food conversion efficiency of *Salmo gairdneri*, Richardson. Journal Fish Biology 11: 87-98.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

Dr. Rich, who founded ***AAR*** in 1983, has had over 30 years of technical and administrative project management experience in a wide range of fisheries-related projects. Dr. Rich's professional experience encompasses work as an expert witness on fisheries issues, fisheries consultant, fisheries biologist, fish physiologist, analytical chemist, and university lecturer. Dr. Rich has worked on projects involving federal, state, and local agencies, private companies, law firms, and environmental non-profit organizations throughout the western states, Maine, British Columbia, and the Bahamas. Dr. Rich has designed and supervised projects involving environmental disasters (human-induced and natural), mining (gravel, gold limestone and phosphate), pollution, hydropower (dams and diversions), lagoons, bridges, dredging and pile driving, road construction, timber harvest, and other types of human land use activities on sensitive fish species. She has supervised hundreds of fish impact studies and analyses, including threatened and endangered fish species surveys and analyses, ESA Section 7 Consultations with federal agencies, fishery resources technical reports for EIR's, EIS's, and other environmental documents, fish risk assessments (mining), instream flow analyses, fish habitat and populations surveys and analyses, fish mitigation and rehabilitation, fish collection/salvage/relocation, fish age determination, fish limiting factor analysis, expert witness testimony, water quality and water temperature monitoring and impact analyses, fish physiology studies, and macro-invertebrate sampling and analyses. In addition, Dr. Rich is an expert in fish physiology and toxicology and has been called upon as an expert witness on the stressful impacts of environmental disasters, pollution, water temperature, dams, diversions and hydroelectric power, salmonid migration barriers, timber harvest, catch-and-release fishing, transportation and handling on fishes, and other factors that can be detrimental to federal- and state-listed fish species.

REPRESENTATIVE EXPERIENCE

- Provided expert witness testimony on wide range of federal- and state-listed fish species on water quality, water temperature, environmental disasters, mining, fish migration, logging, land development, and other factors that affect sensitive fish species;
- Designed and supervised over 50 water temperature and water quality monitoring for studies that focused on salmon, steelhead, and other threatened- and endangered-listed fish species.
- Supervised hundreds of studies on threatened, endangered, and candidate fish species throughout California, Nevada, and Idaho, including the threatened Central California Coast steelhead, endangered Southern steelhead, threatened Northern California steelhead, endangered Central California Coast coho salmon, threatened Southern Oregon/Northern California coast coho salmon, threatened Central Valley spring-run Chinook salmon, endangered Sacramento River winter-run Chinook salmon, endangered razorback sucker, Owens pupfish, endangered Owens tui chub, threatened delta smelt, endangered tidewater goby, threatened South Central California Coast steelhead, North American green sturgeon, threatened North American green sturgeon, threatened Lahontan cutthroat trout, endangered Pahranagat roundtail chub, and other federal- and state-listed fish species.
- Designed and implemented multi-year studies that focused on the impacts of streamflows, water quality and water temperature from hydropower, dams and diversions, pile driving, mining, dredging, oil and other pollutants, pile driving, road construction, levee construction, boat docks, boat activities, and marinas involving Federal- and state-listed fish species.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

***REPRESENTATIVE EXPERIENCE* (cont.)**

- Designed and supervised thermal physiology studies to determine the optimal growth temperature for juvenile Chinook salmon in the Central Valley, California.
- Expert witness testimony on the effects of discharge effluent from a scrap metal company on salmon and steelhead in the Feather River.
- Expert witness testimony on the thermal impacts of PG&E's De Sabla-Centerville project on spring-run Chinook salmon in the Butte Creek and west Branch Feather River systems.
- Assessment and expert witness testimony of fishery resources impacts of multi-year flow/water temperature studies on the American River, California.
- Designed and supervised studies (fish habitat and population surveys; heavy metal analysis; fish bioenergetics-growth studies; macro-invertebrate bioassessment) on the impacts of the expansion of a gold and phosphate mines in Idaho and Nevada.
- Designed and supervised studies (fish habitat and population surveys; heavy metal analysis; fish bioenergetics-growth studies; macro-invertebrate bioassessment) on the impacts of the expansion of a gold mine on spring-run Chinook salmon, steelhead trout, bull trout, and westslope cutthroat trout in the Salmon River Watershed, Idaho.
- Designed and supervised studies (water temperature and water quality) on the impacts of the expansion of a gold mine on fishes Humboldt River Watershed, Nevada.
- Biological Assessment and fish relocation and Section 7 Consultation assistance with NOAA Fisheries, U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers
- Assessment of potential fishery resources impacts of the replacement of the Lewiston Dam Power Plant in Trinity County, California.
- Assessment of potential impacts on salmonids, delta smelt, and Sacramento splittail of diverting 15,000 acre-feet per year of Sacramento Municipal Utility District's American River entitlement to Sacramento County, California.
- Assessment of thermal impacts of reduced flows on Chinook salmon and steelhead in the Yuba River, California;
- Determined on-site restoration measures to provide additional habitat for a variety of Threatened and Endangered fish species including steelhead, delta smelt, winter-run Chinook salmon, spring-run Chinook salmon, Central Valley fall and late-fall Chinook salmon, North American green sturgeon, longfin smelt, and Sacramento splittail, and razorback suckers.
- Designed and supervised hundreds of fish habitat (e.g.,habitat typing, Essential Fish Habitat, Shaded Riverine Aquatic Habitat, etc.) and population surveys throughout the Central Valley and other parts of California and the other western states.
- Supervised studies on the impacts of gravel mining on salmon and trout in the Mad and Eel Rivers Watershed in northern California.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE EXPERIENCE (cont.)

- Written over 100 Biological Assessments and fishery resources technical reports for EIR's, EIS's, and other environmental documents on the effects of a variety of land uses on threatened and endangered fish species throughout California.
- Worked extensively with federal, state, and local agencies and facilitated permitting and other agreements with applicants/clients throughout all phases of projects for over 30 years.
- Supervised fish habitat and population (electrofishing, beach seining, snorkeling, fyke nets) studies on over 100 projects involving salmon and trout and other Federal- and state-listed fish species.
- Designed watershed-based fish restoration projects for over 30 years.
- Trained field crews for over 30 years on minimizing handling and transportation stress on fishes in marine, estuarine, and freshwater ecosystems.
- Designed and supervised projects involving fish migration, including mapping (GIS) potential migration barriers and follow-up studies to determine whether or not barriers prevented fish (anadromous and resident) migration.
- Supervised fish rescue and relocation of dozens of construction-related projects, involving federal- and state-listed fish species.
- Analyzed methods used to determine behavioral impacts of dredging on fishes throughout the world.
- Supervised a study on the impacts of past, present, and future gravel mining on steelhead in the Upper Russian River Watershed.
- Dredge-related ESA Section 7 Consultations with NOAA Fisheries, U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers for the River Islands Development Project in Lathrop, California.
- Impacts of boat docks on salmonids in the Calaveras River Watershed in connection with the Brookside Estates Project, Stockton, California.
- Impacts of maintenance dredging by the Sacramento Yacht Club on the North American Green sturgeon in West Sacramento, California.
- Impacts of dredging activities on the behavior of federal- and state-listed fishes in San Francisco Bay.
- Impacts of suspended sediments resulting from dredging activities on federal- and state-listed fishes in San Francisco Bay.
- Supervised fish age studies (scales, otoliths, fin rays) in numerous freshwater and marine fishes.
- Trained in the Instream Flow Incremental Methodology (IFIM) and Habitat Evaluation Procedures (HEP).

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

EXPERT WITNESS TESTIMONY

- Impacts of effluent from a scrap metal facility on federal- and state-listed fish species (*Cannata, Ching & O'Toole, LLP, San Francisco, California*)
- Analysis of City of Napa's Mitigated Negative Declaration for the Napa Creek Apartments Project, Napa (Dan Muller, Attorney,
- Thermal Impacts from Diversions from the Delta Wetlands Project on Chinook Salmon and other Fishes of the Sacramento-San Joaquin River System (*Central Delta Water District, Stockton, California*)
- Thermal Impacts of Yuba County Water Agency's Proposal to Reduce Flows in the Lower Yuba River on Chinook Salmon and Steelhead Trout in the Yuba River (*California Department of Fish and Game, Sacramento, California)*
- Impacts of Reduced Flows on the Fishery Resource Habitat of the Lower American River (*County of Sacramento, California*
- Thermal Impacts of Altered Stream Flows on the Fishery Resources of the Lower American River (*County of Sacramento, California*)
- Thermal Impacts from Diversions from the Delta Wetlands Project on Chinook Salmon and other Fishes of the Sacramento-San Joaquin River System (*California Department of Fish and Game, Sacramento, California*)
- Impacts of Proposed Board of Forestry's Amendment to the Board of Forestry Rules on Salmon and Trout (*California Forestry Association, Sacramento, California*)
- Impacts of Sediment Associated with Timber Harvesting on Salmonids (*California Forestry Association, Sacramento, California*)
- Impacts of Sediment Associated with Vineyard Development on Salmonids (*Morrison and Foerster, Attorneys, San Francisco, California*)
- Impacts of Streamflow Alterations on Emigrating Salmonids *(North Marin County Water District, Novato, California)*
- Impacts of Streamflow Alterations on Emigrating and Resident Salmonids (*Casa de Fruta, Hollister, California)*
- Impacts of Summer Dams on Aquatic Species (*North Marin Water District, Novato, California)*
- Impacts of Handling and Transportation on Fresh Salmon (Alaska Airlines, Seattle, Washington)
- Stressful Impacts of Handling and Transportation on Salmonids (*Bangor Hydro-Electric Company, Bangor, Maine)*
- Impacts of Timber Harvest Practices on Salmonids *(East Bay Municipal Water District, Oakland, California)*
- Impacts of Timber Harvest Practices on Salmonids (*Barnum Timber Company, Eureka, California*)
- Impacts of Roads, Bridge, and Vineyard on Salmonids (*Friends of West Union Creek, Woodside, California)*

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

EXPERT WITNESS TESTIMONY (cont.)

- Impacts of Construction of an Oil Rig Platform on the Fishery Resources (primarily herring) of Northern Puget Sound (*Kiewit Construction Company, Bellingham, Washington)*
- Impacts of Dropping Crates of Fresh Salmon on the Marketability of the Salmon as Food (*Alaska Airlines, Seattle, Washington)*

EDUCATION

- Ph.D., 1983. Fisheries, University of Washington, Seattle
- M.S., 1979. Fisheries, University of Washington, Seattle
- B.S., 1973. Zoology, University of California, Davis

PROFESSIONAL HISTORY

- A. A. Rich and Associates/Principal (1983-present)
- University of Washington, School of Fisheries/Lecturer (1982-1983)
- University of Washington, School of Fisheries/Teaching Assistant (1976-1983)
- University of Washington, School of Fisheries, Laboratory of Radiation Ecology/Analytical Chemist (1977-1980)
- U.S. Forest Service, Seattle/Fisheries Consultant (1980)
- U.S. Bureau of Reclamation, Sacramento, California/Fisheries Biologist (1975)
- California Department of Fish and Game, Sacramento/Fisheries Biologist (1973-1975)

CERTIFICATIONS

- IFG 200-Designing and Conducting Studies Using IFIM. Instream Flow Group, U. S. Fish and Wildlife Service, West Virginia, 1984.
- IFG 205-Field Techniques for Instream Analysis. U. S. Fish and Wildlife Service, West Virginia, 1984.
- IFG-210-PHABSIM-Using the Computer-Based Physical Habitat Simulation System. U. S. Fish and Wildlife Service, Colorado, 1984.
- Habitat Evaluation Procedures (HEP), Colorado, 1985.
- Fish Bioenergetics Growth Models, Toronto, Canada, 1988.
- SCUBA, N.A.U.I.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

PROFESSIONAL AFFILIATIONS

- American Association for the Advancement of Science
- American Fisheries Society
- American Association of University Women
- Professional Environmental Marketing Association
- Western Dredging Association

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED

Dr. Rich has published and presented papers on a number of fishery resources topics including: water temperature and water quality impacts of flow alterations on delta smelt, salmon, steelhead, and other Federal- and state-listed fish species throughout the Central Valley; gravel, gold, and phosphate mining on salmonids; water quality requirements for fishes; dredging impacts on fishes; impacts of catch-and-release fishing on salmonids; smoltification of salmonids; enhancement strategies of salmonids in urban and rural areas; impacts of logging on salmon and trout habitat and populations; impacts of rotenone on lake fishery resources; domestication of salmonids; preferred herring spawning substrates; and, exercise physiology of trout. Following is a list of representative publications and papers presented.

Rich, A. A. 2014. Middle Green Valley Specific Plan Project-DEIR/Potential Significant Impacts on the Threatened Central California Coast Steelhead (*Oncorhynchus mykiss*); California Red-Legged Frog (*Rana draytonii*); and, Western Pond Turtle (*Actinemy marmorata*), in Green Valley Creek. Expert Testimony Prepared for the Solano County Board of Supervisors, Fairfield, California on behalf of the Upper Green Valley Homeowners. November 25, 2014. 10 pages + Attachment and Exhibit.

Rich, A. A. 2014. Replacement of the Oak Ridge Drive Bridge, Roseville, Placer County. Fishery Resources Biological Assessment. Prepared for RBF Consulting, Sacramento, California. October 8, 2014. 36 pages +Appendices.

Rich, A. A. 2014. Study Elements required to Determine Salmonid Habitat and whether or not there are Factors that would Limit Salmonid Production in Permanente Creek Upstream of the Diversion Channel, Santa Clara County, California. Prepared for CSW/Stuber-Stroeh Engineers. March 3, 2014. 24 pages.

Rich, A. A. 2014. Knights Landing River Access Boat Launching Facility Renovation, Yolo County-Biological Assessment. Prepared for Yolo County, Woodland. February 19, 2014. 60 pages + Appendices.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (cont.)

Rich, A. A. 2014. Expert Witness Testimony-City of Napa's Revised Initial Study/Mitigated Negative Declaration for Napa Creek Apartments Project. Prepared for Daniel Muller, Attorney, Walnut Creek. June 18, 2013. 5 pages.

Rich, A. A. 2013. Expert Witness Testimony: Declaration of Alice A. Rich, Ph.D. in the matter of the People of the State of California, Petitioner, vs George W. Scott, Sr. Respondent. Prepared for Cannata, Ching & O'Toole LLP, Attorneys, San Francisco, California. May 9, 2013.

Rich, A. A. 2013. Anadromous Salmonid Culvert Analysis I-80 Express Lanes Project. Prepared for the Solano Transportation Authority and CalTrans. October 30, 2013. 13 pages + Appendices.

Rich, A. A. 2013. Bank Stabilization Project at 21 Banchero Way, Fairfax, California. Fish Collection and Relocation Plan. Prepared for Village West, Fairfax, California. August 13, 2013.

Rich, A. A. 2013. Bank Stabilization Project at 48 Broadmoor Avenue, San Anselmo, California. Fish Collection and Relocation Plan. Prepared for the Williamsons, San Anselmo, California. August 12, 2013.

Rich, A. A. 2013. Green Gulch Zen Center Landslide Stabilization Project. Muir Beach, California. Biological Assessment. Prepared for the San Francisco Zen Center, June 20, 2013.

Rich, A. A. 2013. Bank Stabilization Project at 48 Broadmoor Avenue, San Anselmo, California. JARPA and Biological Assessment. Prepared for Brian and Melisa Williamson, San Anselmo, California. June 10, 2013.

Rich, A. A. 2013. Charro Way Pipe Replacement Project, Fairfax, California. JARPA and Biological Assessment. Prepared for Village West Homeowners, Fairfax, California. June 6, 2013.

Rich, A. A. 2013. Bank Stabilization Project at 21 Banchero Way, Fairfax, California. JARPA and Biological Assessment. Prepared for Village West Homeowners, Fairfax, California. May 30, 2013.

Rich, A. A. 2012. Interpreting water temperature impacts from streamflow alterations from hydroelectric power, mining, and other land use activities on coldwater fishes, such as salmon and trout. Prepared for Technical Advisory Services for Attorneys (TASA), December, 2012. Submitted for the TASA January, 2013 Newsletter.

Rich, A. A. 2012. Southern California Edison's Kaweah River Hydroelectric Power Intake 2 Modification Project, Tulare County, California - Fish Rescue and Relocation. Prepared for Southern California Edison. October 19, 2012. 10 pages + Appendices

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (cont.)

Rich, A. A. 2012. Brannan Street Wharf Pile Driving Project, San Francisco, California - Fishery Resources Monitoring Final Report. Prepared for the Port of San Francisco. December 27, 2012. 7 pages + Appendices.

Rich, A. A. 2012. The La Goma Project, 5-19 La Goma Avenue, Mill Valley - Potential Impacts of Contaminants on the Steelhead in Arroyo Corte Madera del Presidio Creek. Prepared for the City of Mill Valley. March 26, 2012. 21 pages +Appendices.

Rich, A. A. 2012. Biological Assessment for Bank Stabilization Project at 700-779 Center Boulevard (FairAnselm), Fairfax, CA. Prepared for Ballard & Watkins, San Anselmo, California. March 7, 2012. 21 pages + Appendices.

Rich, A. A. 2012. PG&E Line 109 External Corrosion Direct Assessments - Fishery Resources Assessment for Two Sites. Prepared for SWCA, Santa Clara County. March 3, 2012. 16 pages+ Appendices.

Rich, A. A. 2011. Heritage Ranch CSD-Gallery Wells Project, Paso Robles, California - Report of Fish Collection and Relocation. Prepared for SWCA, San Luis Obispo. October 14, 2011. 8 pages + Appendix.

Rich, A. A. 2011. Expert Witness on behalf of CalTrans regarding Contract No. 04-0A724 Potable Water Discharge, City of Woodside, California, Fish Kill in Bear Gulch Creek, Follow-Up Report. Prepared for CalTrans, June 24, 2011. 4 pp + Appendices

Rich, A. A. 2011. Sacramento Yacht Club Maintenance Dredging Project-Potential Impacts on the North American Green Sturgeon. April 2011. 23 pp + Appendices

Rich, A. A. 2011. USFWS Fishery Resources Evaluation for the Pahranagat National Wildlife Refuge. March 28, 2011. Prepared for Harris Environmental Group, Tucson, Arizona. 13 pages.

Rich, A. A. 2011. Lewiston Dam Powerplant Replacement Project, Trinity County-Fishery Resources Technical Report. Prepared for Sunrise Engineering, Utah. February 7, 2011. 47 pp + Appendices.

Rich, A. A. 2010. Potential Impacts of Re-Suspended Sediments Associated with Dredging and Dredged Material Placement on Fishes in San Francisco Bay, California -Literature Review and Identification of Data Gaps. Prepared for the U.S. Army Corps of Engineers, San Francisco. Draft Report. July 20, 2010. 75 pp + Appendices.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (cont.)

Rich, A. A. 2010. Tools for Assessing and Monitoring Fish Behavior Caused by Dredging Activities. Prepared for the U.S. Army Corps of Engineers, San Francisco. Draft Report. June 23, 2010. 77 pp + Appendices.

Rich, A. A. 2010. Little Hastings Island Proposed Conservation Bank, Solano County, California. Fishery Resources Rehabilitation: An Analysis. Prepared for Wildlands, Inc., Rocklin, California. May 7, 2010. 89 pp + Appendices.

Rich, A. A. 2009. San Francisco Public Utilities Commission Calaveras Dam Replacement Project Public Draft EIR-Technical Comments on Fishery Resources Issues. Prepared for Weinberg, Roger & Rosenfeld, Alameda, California. December 21, 2009. 14 pp.

Rich, A. A. 2009. River Islands at Lathrop Project - Fishery Resources Technical Report. Prepared for Califia, Inc., Lathrop, California. November 11, 2009. 71 pp + Appendices.

Rich, A. A. 2009. River Islands at Lathrop Project - Potential Impacts of Water Temperature on Federal- and StateListed Fish Species. Prepared for Califia, Inc., Lathrop, California. November 11, 2009. 15 pp.

Rich, A. A. 2009. River Islands at Lathrop Project - Potential Impacts of Stormwater Runoff and Golf Course Discharge on Federal- and State-Listed Fish Species. Prepared for Califia, Inc., Lathrop, California. November 11, 2009. 46 pp.

Rich, A. A. 2008. Fishery Resources Conditions of the Alhambra Creek Watershed, Contra Costa County. Prepared for the Urban Creeks Council, Berkeley, California. July 25, 2008. 53 pages.

Rich, A. A. 2008. A Salmonid Monitoring Plan for Codornices Creek. Prepared for the Urban Creeks Council, Berkeley, California. May 23, 2008. 71 pages.

Rich, A. A. 2008. A Trout and Salmon Guide to the Urban Creeks and Rivers that Flow into San Francisco Bay. Prepared for the Urban Creeks Council, Berkeley, California. April 20, 2008. 47 pages.

Rich, A. A. 2008. Codornices Creek Restoration Project at Albina Avenue, Berkeley, California-Pre-Construction Relocation of Fishes. Prepared for the U. S. Fish and Wildlife Service, Santa Rosa, California. February 5, 2008. 12 pages.

Rich, A. A. 2008. Biological Resources Assessment for the Draper Project, 560 Inverness Road, Inverness, California. Prepared for the Drapers, Inverness, California. February 4, 2008. 14 pages + Appendices.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (Cont.)

Rich, A. A. 2007. Impacts of Water Temperature on Fall-Run Chinook Salmon (*Oncorhynchus tshawytscha*) and Steelhead (*O. mykiss*) in the San Joaquin River System. Prepared for the California Department of Fish and Game, Fresno, California. September 24, 2007. 44 pages.

Rich, A. A. 2007. PG&E's DeSabla-Centerville Hydropower Project - Comments on the Thermal Effects of PG&E's DeSabla-Centerville Project on Spring-run Chinook Salmon (*Oncorhynchus tshawytscha*). Prepared for the California Sportfishing Protection Alliance, Berkeley, California. August 23, 2007. 25 pages plus Appendices.

Rich, A. A. 2007. Napa Creek Flood Wall Construction-Pre-Project Relocation of Fishes. Prepared for the U. S. Fish and Wildlife Service, Sacramento, California. August 7, 2007. 6 pages + Appendices.

Rich, A. A. 2007. Fishery Resources Technical Report for Napa County General Plan. Prepared for Napa County, Napa, California. January 2007. 110 pages plus Appendices.

Rich, A. A. 2006. Fishery Resources Assessment for the Town of Fairfax. Prepared for the Town of Fairfax, Department of Public Works. December 18, 2006. 77 pages plus Appendices.

Rich, A. A. 2006. The 505 Miller Avenue Project, Mill Valley. Biological Assessment. Prepared for Skyline/Miller/House, LLC. October 27, 2006. 33 pages + Appendices

Rich, A. A. 2006. Biological Assessment for the Bank Failure Project at 323/325 Bolinas Road, Fairfax. Prepared for the Wassermans. September 19, 2006. 31 pages.

Rich, A. A. 2006. Biological Assessment for Bank Failure Project at 39 Cascade Drive, Fairfax. Prepared for Steve Katz. September 10, 2006. 26 pages.

Rich, A. A. 2006. Biological Assessment for Bank Failure Project at 91 Mt. Tallac Court, San Rafael. Prepared for the Moreno Family. September 7, 2006. 35 pages.

Rich, A. A. 2006. Critique of NOAA Fisheries Report Entitled *Monitoring Sediment Delivery to Streams Following Vineyard Development from Forested Lands and the Effects on Steelhead Trout.* Submitted to the California Board of Forestry. Prepared for Morrison & Foerster, Attorneys, San Francisco. August 7, 2006. 33 pages.

Rich, A. A. 2006. Redwood Lodge, Mill Valley-Assessment of Fishery Resources Habitat Conditions in Arroyo Corte Madera del Presidio Creek. Prepared for Clearwater Hydrology, Berkeley. May 30, 2006. 19 pages.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (Cont.)

Rich, A. A. 2006. Construction of 18-Unit Residential Building at 5-19 La Goma Avenue, Mill Valley. Biological Assessment. Prepared for CirclePoint, San Francisco. May 17, 2006. 31 pages + Appendices.

Rich, A. A. 2005. Fish Relocation Summary of Results for Town of Ross (Marin County) Annual Dredging. Prepared for NOAA Fisheries, November 8, 2005. 10 pages.

Rich, A. A. 2005. SFPP Pipeline Inspection and Repairs-Summary Results of Collection and Relocation of Fishes in Donner Creek, Nevada County, California. Prepared for U.S. Fish and Wildlife Service and California Department of Fish and Game. November 2, 2005. 10 pages.

Rich, A. A. 2005. Carmel River Lagoon Mechanical Breaching- Steelhead Issues. Prepared for the Carmel Point and Lagoon Preservation Association. August 7, 2005. 37 pp.

Rich, A. A. 2005. River Islands Project - Fishery Resources Technical Report. Prepared for River Islands at Lathrop, California. April 21, 2005. 85 pp + Appendices.

Rich, A. A. 2005. Replacement of Deck at #14 and #16 Creek Lane, Mill Valley. Biological Assessment. Prepared for Cascade Properties, Boulder, Colorado. February 2005. 34 pp + Appendices.

Rich, A. A. 2004. Bank Stabilization at 1 Sylvan Lane, Marin County, Relocation of Fishes. Prepared for the U.S. Corps of Engineers, San Francisco, CA. March 29, 2004. 8 pp + Appendices.

Rich, A. A. 2004. Fishery Resources Conditions at Emmerson, Blue Lake, Johnson, and Graham Bars. Prepared for Granite Construction Company, Eureka, Ukiah, California. March 8, 2004. 36 pp + Appendices.

Rich, A. A. 2003. Fishery Resources Conditions of Suscol Creek, Napa County, California. Prepared for Friends of the Napa River. April 21, 2003. 68 pp + Appendices.

Rich, A. A. 2003. Long-term Water quality and Temperature Monitoring for Boat Dock Construction at the Brookside Estates in Stockton, California. Summary of Results of 2002 Data. Prepared for Brookside Development Associates, Stockton. April 4, 2003. 25 pp + Appendices.

Rich, A. A. 2002. Results of Presence/Absence Fishery Resources Electro fishing Survey within the North Branch of the South Fork Littlejohns Creek, San Joaquin County. Prepared for Forward Inc., Manteca, California. June 25, 2002. 9 pp + Appendices.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (Cont.)

Rich, A. A. 2002. On-Site Biological Monitoring for Boat Dock Installation and Construction at Brookside Estates in Stockton, California. Prepared for Brookside Development Associates, Stockton. April 19, 2002. 22 pp + Appendices.

Rich, A. A. 2002. Bahia Dredging and Lock Project Environmental Assessment for Fishery Resources. Prepared for Bahia Homeowners' Association, Novato, California. February 22, 2002. 62 pp + Appendices.

Rich, A. A. 2002. Environmental Assessment for the Chaplinsky Boat Ramp to Pier Conversion at 93 Shoreline Circle, Incline Village, Lake Tahoe, Nevada. Prepared for R. Chaplinsky. January 18, 2002. 36 pp + Appendices.

Rich, A. A. 2001. Noyo River Fish Monitoring 2000 Summary Report. Prepared for the City of Fort Bragg, Fort Bragg, California. April 25, 2001. 25 pp + Appendices.

Rich, A. A. 2001. Response to the California Department of Fish and Game's February 2, 2001 Testimony presented to the California Fish and Game Commission with regard to listing coho salmon (*Oncorhynchus kisutch*) as an endangered species. Testimony submitted to the California Fish and Game Commission. April 3, 2001. 26 pp.

Rich, A. A. 2001. Response to the Salmon and Steelhead Recovery Coalition Petition submitted to the California Fish and Game Commission to list coho salmon (*Oncorhynchus kisutch*) as an endangered species. Testimony submitted to the California Fish and Game Commission. January 31, 2001.

Rich, A. A. 2000. Fishery Resources Conditions of the Corte Madera Creek Watershed, Marin County, California. Prepared for Friends of Corte Madera Creek Watershed, Larkspur, California. November 10, 2000. 120 pp. + Appendices.

Rich, A. A. 2000. Aguas Frias Road Bridges-Impacts on Fishery Resources, Chico, Butte County, California. Prepared for Eco-Analysts, Chico, California. October 25, 2000. 29 pp.

Rich, A. A. 2000. Oral Testimony of Alice A. Rich Presented to the California State Water Resources Control Board in the Matter of the Delta Wetlands Project Regarding Water Right Applications 29062, 29066, 30268, and 30270 and Petitions to Change these Applications. September 15, 2000.

Rich, A. A. 2000. Brookside Dock Expansion Environmental Assessment for Fishery Resources-Addendum. Prepared for Brookside Development Associates, Stockton. September 4, 2000. 67 pp. + Appendices.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (Cont.)

Rich, A. A. 2000. Brookside Dock Expansion Environmental Assessment for Fishery Resources. Prepared for Brookside Development Associates, Stockton. July 10, 2000. 6 pp. + Appendices.

Rich, A. A. 2000. Potential impacts of the proposed Congregation Beth El Synagogue and School on the fishery resources of the Codornices Creek Watershed, Alameda County, California. Prepared for the City of Berkeley. June 26, 2000. 50 pp. + Appendix.

Rich, A. A. 2000. Testimony of Alice A. Rich, Ph.D. Submitted to the State Water Resources Control Board by the California Department of Fish and Game Regarding the Yuba River Hearings. May 1, 2000.

Rich, A. A. 2000. The potential impacts of the emergency work performed at the Kendall Ranch on the fishery resources of the Garcia River, Mendocino County. Prepared for Rawles, Hinkle, Carter, Behnke & Oglesby, Attorneys, Ukiah. February 9, 2000.

Scientific Review Panel. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and Salmonid Habitat. Prepared for The Resources Agency of California and the National Marine Fisheries Service, Sacramento, California, June, 1999. June 1999. 92 pp + Appendices.

Rich, A. A. 1999. FMC Phosphate Mine Expansion, Fishery Resources Technical Report. Prepared for FMC Phosphate Mine, Soda Springs, Idaho. February 5, 1999. 100 pages + Appendices.

Rich, A. A. 1999. Fishery Resources Conditions in Pine and Mill Creek Watersheds, Rovana, Inyo County, California. Prepared for Inyo County. January 11, 1999. 48 pp + Appendices.

Rich, A. A. 1999. Ventura River Fish Survey and Fish Relocation Results. Submitted to the National Marine Fisheries Service as part of Section 7 (ESA) Consultation. January 4, 1999.

Rich, A. A. 1999. Leeville Gold Mine Expansion Project, Carlin, Nevada. Fishery Resources Technical Report. Prepared for Newmont Gold Company, Carlin, Nevada. January 1999.

Rich, A. A. 1998. Fishery Resources Conditions of Adobe Creek, Petaluma, Sonoma County, California. Prepared for the Petaluma Planning Department, December 8, 1998. 46 pp.

Rich, A. A. 1998. Assessment Plan for the Talache Mine Mill Tailings Site, Atlanta, Idaho. Prepared for Monarch Greenback, Boise, Idaho, April 14, 1998. 36 pp + Appendix.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (Cont.)

Rich, A. A. 1998. Talache Mine Tailings Project, Preliminary Review of Existing Information on Fishery Resources Conditions. Prepared for Monarch Greenback, Boise, Idaho. April 24, 1998. 71 pp + Appendices.

Rich, A. A. 1997. Noyo River Fish Monitoring 1997 Summary Report. Prepared for the City of Fort Bragg, Fort Bragg, Mendocino, California. December 30, 1997. 36 pp + Appendix.

Rich, A. A. 1997. Ord Ferry Road Bridge Seismic Retrofit Project, Impacts on Fishery Resources, Butte County, California. Prepared for Butte County. November 25, 1997. 27 pp + Appendix.

Rich, A. A. 1997. Testimony of Alice A. Rich, Ph.D., Submitted to the State Water Resources Control Board, Regarding Water Rights Applications for the Delta Wetlands Project. July 1997, on behalf of the California Department of Fish and Game, Exhibit 7, 88 pp + Appendix.

Rich, A. A. 1997. Novato Creek Flood Control Project, Marin County. Fishery Resources Conditions. Prepared for the County of Marin, California. June 19, 1997. 23 pp + Appendices.

Rich, A. A. 1997. Stibnite Mine Expansion Payette National Forest Draft Fishery Resources Technical Report. Prepared for U.S.F.S., Payette National Forest, McCall, Idaho. April 25, 1997. 172 pp + Appendices.

Rich, A. A. 1997. Aggregate Resources Management Plan for the Upper Russian River-Status of Fishery Resources. Prepared for Philip Williams & Associates, San Francisco, February, 1997. 98 pp + Appendices.

Rich, A. A. and S. Li. 1997. Fishery Resources Assessment for a Project to Assign 15,000 Acre-Feet Per Year of Sacramento Municipal Utility District's (SMUD) American River Water Entitlement to Sacramento County. Prepared for SMUD, Sacramento, 1997.

Rich, A. A. 1996. Novato Creek Flood Control Project, Marin County. Fishery Resources Conditions from Diablo Avenue to Grant Avenue-Reconnaissance-Level Survey. Prepared for the County of Marin. May 31, 1996. 19 pp.

Rich, A. A. 1995. Results of age analysis of fishes (English sole) from the Yukon and British Columbia. Prepared for Norecol Dames & Moore, British Columbia, Canada, December 19, 1995. 30 pp.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (Cont.)

Rich, A. A. 1995. The potential impacts of the Serra Estrellada Project on the Fishery resources of the Redwood Creek Drainage, Alameda County. Prepared for Alameda County Planning Department, Hayward, California. October 2, 1995. 34 pp.

Rich, A. A. 1995. Mitigation measures and habitat analysis for fishery resources of San Joaquin County-Habitat Conservation Plan. Prepared for Toyon Environmental Consultants, Kentfield, California. September 15, 1995. 12 pp.

Rich, A. A. 1995. The potential impacts of the Pearson Project on the fishery resources of West Union Creek, San Mateo County. Prepared for Friends of West Union Creek, Woodside, California. September 5, 1995. 43 pp + Appendix.

Rich, A. A. 1995. Potential impacts of the Klyce Project on the fishery resources of Slide Gulch Creek in Mill Valley, Marin County. Prepared for the Babcock Family, Mill Valley, California. August 14, 1995. 23 pp + Appendix.

Rich, A. A. 1995. Feasibility study to rehabilitate the fishery resources of the Arroyo Corte Madera del Presidio Watershed, Mill Valley, California. A. A. Rich and Associates. May 31, 1995. 74 pp + Appendices.

Rich, A. A. 1994. West Lathrop Specific Plan Fishery Resources Assessment. Prepared for Sycamore Environmental Consultants, Sacramento, California. September 30, 1994. 61 pp.

Rich, A. A. 1994. Central Valley Project Improvement Act Programmatic EIS: Anadromous Fish Restoration
Projects. Prepared for Jones & Stokes Associates, Sacramento, California. August 31, 1994. 96 pp + Appendices.

Rich, A. A. 1994. A reconnaissance-level study of the fishery resources of the Pilarcitos Creek Watershed.
Prepared for the San Francisco Water Department, Millbrae, California. May 20, 1994. 49 pp + Appendices.

Rich, A. A. 1994. The potential impacts of the Fort Bragg Water Resources Development Project on the Fishery Resources of the Noyo River, Mendocino County. Prepared for the City of Fort Bragg. May 4, 1994. 54 pp + Appendices.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (Cont.)

Rich, A. A. 1993. State of California Wildlife Conservation Board Boat Ramp Renovation Project-Fishery Resources. Prepared for Harland Bartholomew & Associates, Sacramento, California. December 3, 1993.

Rich, A. A. 1993. Technical Memorandum on the Impacts of the Implementation of the Reclamation Reform Act on Aquatic Resources in the Central Valley. Prepared for the U.S. Bureau of Reclamation, Denver, Colorado. January 1993. 71 pp + Appendix.

Rich, A. A. 1992. Biological Assessment for Proposed Sewer pipeline, City of Sutter Creek, Amador, California. Prepared for Baracco and Associates, Sutter Creek. October 31, 1992. 26 pp + Appendix.

Rich, A. A. 1992. Feasibility study to rehabilitate the fishery resources of Easkoot Creek, Marin County. Prepared for the Environmental Action Committee of West Marin, Point Reyes Station. May 1992. 47 pp. + Appendices.

Rich, A. A. 1992. Fishery Resources of Dry Creek and Pleasant Grove Creek, Roseville, California. Prepared for James M. Montgomery Consulting Engineers, Walnut Creek. January 6, 1992. 35 pp.

Rich, A. A. 1993. Vallejo fishing pier replacement fishery resources assessment. Prepared for Greiner, San Ramon. November 26, 1993. 10 pp.

Rich, A. A. 1993. A Reconnaissance-Level Survey of Existing Fishery Resources Habitat Conditions on the
Lemelson Property, Incline Village, Nevada. Prepared for Jerome Lemelson, Incline Village, Nevada. September 29, 1993. 28 pp + Appendices

Rich, A. A. 1993. Alameda Watershed Fishery Resources Evaluation of Existing Data. Prepared for the City and County of San Francisco. August, 1993.

Rich, A. A. 1993. Fishery resources of Auburn Ravine and Pleasant Grove Creeks, Roseville, California. Prepared for the City of Roseville, California. February 16, 1993. 14 pp.

Rich, A. A. 1993. Weber Creek Fishery Resources Evaluation of Existing Data. Prepared for the El Dorado Irrigation District, Placerville. February 5, 1993. 27 pp.

Rich, A. A. 1991. Salmonid habitat conditions and population estimates in Forest Creek and the Middle Fork of the Mokelumne River, California. Prepared for East Bay Municipal Utility District. November 14, 1991. 55 pp. + Appendices.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (Cont.)

Rich, A. A. 1991. Pieta Creek Basin Stream Assessment: 1989-1991. Prepared for the Mendocino County Resource Conservation District, Ukiah, California. October 4, 1991. 52 pp + Appendices.

Rich, A. A. 1991. Mortality and Stress on Salmonids as a Result of Fishery Resources Management Actions. Part 1: The Stressful Effects of Catch-and-Release Fishing on Salmonids. Prepared for Bangor Hydro-Electric Company, Bangor, Maine. May 31, 1991. 57 pp.

Rich, A. A. 1991. The Impacts of Stress on Salmonids as a Result of Fishery Resources Management Actions. Part 2: The Stressful Effects of Handling, Transportation and Tagging on Salmonids. Prepared for Bangor HydroElectric Company, Bangor, Maine. August 1991. 67 pp.

Rich, A. A. and W. E. Loudermilk. 1991. Preliminary Evaluation of Chinook Salmon Smolt Quality in the San Joaquin Drainage. Prepared for the Calif. Dept. Fish and Game, Region 4, Fresno, California. February 18, 1991. 76 pp.

Rich, A. A. 1991. The impacts of timber harvest practices on the fishery resources of the Navarro River Watershed, Mendocino County, California. Phase III: Fishery resources baseline surveys. Annual Report. Prepared for Louisiana-Pacific Corporation, Samoa, California. July 7, 1991. 109 pp. + Appendices

Rich, A. A. 1991. Potential impacts of the Casa de Fruta expansion on the fishery resources in Pacheco Creek, Santa Clara County, California. Prepared for David Powers & Associates, San Jose. February 15, 1991. 14 pp + Appendix.

Rich, A. A. 1990. Pieta Creek Basin Stream Assessment: 1989-1990. Prepared for the Mendocino County Resource Conservation District, Ukiah, California. October 1, 1990. 52 pp. + Appendices.

Rich, A. A. 1990. Restoration of coho salmon and steelhead trout stocks in the Walker Creek Watershed, Marin County, California. Prepared for the California Coastal Conservancy. October, 1990.

Rich, A. A. 1990. The use of smolt and stress indicators as management tools in the San Joaquin Drainage, California. American Fisheries. Society Symposium Proceedings, September 18-22, 1990, Humboldt State University, Arcata, California.

Rich, A. A. 1990. Salmonid habitat conditions in Sproul Creek, Humboldt County, California. Prepared for Barnum Timber Company, Eureka, California. August 31, 1990. 19 pp + Appendices.

Rich, A. A. 1990. Route 85-Coyote Creek mitigation site conceptual revegetation plan: fishery resources conditions. Prepared for H. T. Harvey and Associates, Alviso, California. August 8, 1990. 26 pp + Appendix

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (Cont.)

Rich, A. A. 1990. Salmonid habitat conditions in Baker Creek, Humboldt County, California. Prepared for Barnum Timber Company, Eureka, California. July 17, 1990. 41 pp + Appendices.

Rich, A. A. 1990. Environmental assessment for the extension of an existing pier at the Croom Family residence, Crystal Bay, Lake Tahoe, Nevada. Prepared for Brisco Enterprises. May 2, 1990. 17 pp + Appendices.

Rich, A. A. 1990. Environmental assessment for the extension of an existing pier at the McClean Family residence, Meeks Bay, Lake Tahoe, California. Prepared for Brisco Enterprises, May 2, 1990. 16 pp + Appendices.

Rich, A. A. 1990. Codornices Creek fishery resources habitat survey and enhancement feasibility study. Prepared for the Department of Water Resources, Sacramento, California. February 28, 1990

Rich, A. A. 1989. How does one assess the impacts of water temperatures on salmonids? Fifteenth Annual Conference of the Humboldt Chapter of the American Fisheries Society, April 22, 1989, Scotia, California.

Rich, A. A. 1989. The cumulative impacts of timber harvest practices on the fishery resources of the Navarro River Watershed, Mendocino County, California. Phase I: Development of a methodology to be used to determine the existing fishery resource conditions in the Navarro River Watershed. Prepared for Louisiana-Pacific Corporation, February 15, 1989. 72 pp + Appendices.

Rich, A. A. 1988. The Giacomini Summer Dam Environmental Assessment. Prepared for Richard Giacomini, Point Reyes Station, California. November 6, 1988. 24 pp + Appendix.

Rich, A. A. 1988. A qualitative assessment of the salmonid habitat in Pilarcitos Creek from Main Street to the mouth of the creek, Half Moon Bay, California. Prepared for Bay Farms, San Ramon, California. July 20, 1988.

Rich, A. A. 1988. A qualitative assessment of the proposed Stone Pine Center on the fishery resources of Pilarcitos Creek, Half Moon Bay, California. Prepared for Inwood Corporation, Woodside, California. July 18, 1988.

Rich, A. A. 1988. A qualitative fisheries survey of Pacheco Creek, Novato, California. Prepared for EIP Associates, San Francisco, California. April 10, 1988. 9 pp.

Rich, A. A. 1988. Results of a fisheries survey in the tidal embayment adjacent to Coyote Creek, Alameda County, California. Prepared for Zentner and Zentner, San Francisco, California. March 15, 1988. 13 pp.

ALICE A. RICH, PH.D., PRINCIPAL

RÉSUMÉ

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (Cont.)

Rich, A. A. 1988. Assessment of water availability and potential conflicts of streamflow withdrawals on rainbow and brown trout in Canyon Creek, El Dorado County, California. Prepared for Eagle Hydro Partners, Millbrae, California. February 29, 1988. 14 pp + Appendix.

Rich, A. A. 1988. Growth and food conversion efficiency of American River juvenile salmon at different temperatures. Twenty-Third Annual Cal-Neva American Fisheries Conference. February 5-6, 1988, Ventura, California.

Rich, A. A. 1988. Qualitative fisheries survey in Richardson Bay, California. Prepared for Martin Jarvis, Attorney, San Francisco, California. February 2, 1988. 8 pp.

Rich, A. A. 1987. The status of knowledge of the steelhead trout, coho salmon, the white sturgeon, the tidewater goby and the opossum shrimp in Lagunitas Creek and its estuary. Prepared for North Marin Water District, Novato, California. November 25, 1987. 62 pp + Appendices.

Rich, A. A. 1987. Report on studies conducted by Sacramento County to determine the temperatures which optimize growth and survival in juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Prepared for the County of Sacramento, California. April, 1987. 52 pp + Appendices.

Rich, A. A. 1986. Fishery resource habitat assessment in the watersheds of Salmon Creek, Willow Creek, the Estero Americano, and Cheney Gulch in Sonoma County, California. Prepared for Circuit Rider Productions, Windsor, California. November 17, 1986.

Rich, A. A. 1986. The potential impact of rubber tires on the fishery resources of Phoenix Lake, Marin County, California. Prepared for Marin Municipal Water District, Corte Madera, California. October 24, 1986. 16 pp.

Rich, A. A. 1986. Fishery issues associated with water diversions: the American River versus the Sacramento-San Joaquin Delta. Prepared for the County of Sacramento, California. February, 1986. 26 pp.

Rich, A. A. 1985. Supplemental temperatures analysis. Prepared for the County of Sacramento, California. May 17, 1985. 24 pp + Appendices.

Rich, A. A. 1985. Re-evaluation of fall Chinook salmon spawning escapement estimates in the lower American River. Prepared for the County of Sacramento, California. March 31, 1985. 17 pp.

Rich, A. A. 1985. Finfishery resources off Grays Harbor, Washington. Prepared for Shapiro and Associates, Seattle, Washington. December 3, 1985. 43 pp.

REPRESENTATIVE PUBLICATIONS AND PAPERS PRESENTED (Cont.)

Rich, A. A. 1985. Fishery resources off Willapa Bay, Washington. Prepared for Shapiro and Associates, Seattle, Washington. July 15, 1985. 29 pp.

Rich, A. A. 1985. Existing finfishery resources in the water adjacent to Eagle Harbor, Cypress Island, Washington. Prepared for Shapiro and Associates, Seattle. February 21, 1985. 22 pp.

Rich, A. A. 1984. Big Soos Creek fishery resource inventory, analysis, and enhancement plan. Prepared for Richard Carothers Associates, Landscape Architects, Seattle, Washington. September, 1984. 35 pp.

Rich, A. A. 1984. Herring spawn adjacent to the proposed Kiewit Marine Facility, Whatcom County, Washington. Prepared for Kiewit Construction Company, Bellingham, Washington. February, 1984. 59 pp.

Rich, A. A. 1984. Evaluation of existing water quality conditions in Whatcom Creek and recommendations for the design of a water treatment facility at the Maritime Heritage Center in Bellingham, Washington. Prepared for Callen Construction Company, Custer, Washington. July, 1984. 59 pp.

Rich, A. A. 1984. Herring spawn adjacent to the proposed Kiewit Marine Facility, Whatcom County, Washington. Prepared for Kiewit Construction Company, Bellingham, Washington. February, 1984. 59 pp.

Rich, A. A. 1983. Smolting: circulating catecholamine and thyroxine levels in coho salmon *(Oncorhynchus kisutch)*. Ph.D. Dissertation, University of Washington, Seattle. 97 pp.

Plisetskaya, E., A. A. Rich, W. W. Dickhoff, and A. Gorbman. 1982. A study of triiodothyronine-catecholamine interactions: their effect on plasma fatty acids in Pacific hagfish, *Eptatretus stouti*. Comparative Biochemistry Physiology. 1982.

Rich, A. A. 1980. The effects of domestication upon the levels of noradrenaline, glucose and lactate dehydrogenase in resting and exercised rainbow trout. Amer. Zool. 20(4): 800.

Rich, A. A. 1980. Feasibility of managing resident trout in Williamson Creek, Washington. Prepared for the U. S. D. A., Forest Service. September 18, 1980. 44 pp + Appendices.

Rich, A. A. 1979. The use of stress to quantitate the survival potential of three strains of trout. M. S. Thesis, University of Washington, Seattle. 65 pp.

ATTACHMENT 3

CLIMATE CHANGE AND THE CHANGING WATER BALANCE FOR CALIFORNIA'S NORTH FORK FEATHER RIVER

Gary J. Freeman[1]

ABSTRACT

Climate change has likely had a large role the changing water balance on northern California's North Fork Feather River (NFFR) in recent years. In addition to changes in both snowpack quantity and timing of the spring snowmelt, some of its subbasins are also revealing a declining trend in water year (October 1 through September 30) runoff, while others do not. Pacific Gas & Electric Company (PG&E) divides the NFFR into multiple subbasins and subbasin reaches for purposes of effectively forecasting runoff and scheduling reservoir releases for hydroelectric operations. In order to effectively manage the hydroelectric resources on this river, at the watershed level as a collective whole, it is important to recognize loss in both data stationarity and trends that change both historical runoff timing and quantity of runoff. NFFR's complex terrain geometry includes a combination of both windward facing slopes and rain-shadowed leeward slopes that result in a mix of climatic gradients. The combined effect of having relatively low elevation and topographic barriers in the form of mountain ridges provide opportunity for both orographic cooling to take place on the windward slopes and compressional warming to take place on the leeward slopes as the airflow of frontal systems pass through the NFFR Basin. On the leeward, rain-shadowed slopes, air descends and warms quickly through compressional heating. Precipitation amounts quickly diminish as the descending air warms and increases its capacity to hold moisture. Both the Lake Almanor and East Branch of the North Fork Feather (EBNFFR) subbasins are two rain-shadowed subbasins that exhibit a declining trend in water year runoff. Trend declines that approach 308 hm^3 (250,000 AF)/year collectively from the two subbasins since the early 1960's were analyzed using a water balance approach to help understand the declining runoff trend in terms of changes taking place at the watershed level. Beginning in the 1970's, increased evapotranspiration is likely taking place in the mixed conifer forests due to rising air temperatures. Increased forest growth and warmer air temperatures are likely two of the contributing causes for the increased evapotranspiration that has taken place in recent years. The decrease in both the low elevation snowpack and the water year runoff has resulted in a decline in hydroelectric output and less outflow of the NFFR into Lake Oroville. (KEYWORDS: climate change, Feather River, orographic, water balance, rain shadow, northern California)

INTRODUCTION

California's Sierra Nevada Mountain Range ends the northern part of its approximately 644 km (400 mi) length in the Feather River Basin. Lake Almanor, a former meadow with several large springs, is located over the ending edge of the southern Cascades' porous volcanics, which in turn encounter the mostly impervious metamorphic rocks at the northern end of the Sierra. The northern Sierra and the Feather River Basin are relatively low elevation compared with the much higher southern Sierra that is often referred to as the 'High Sierra', which is often defined as starting its northern end in the headwaters above Yosemite Valley and extending southward along the Sierra crest. Uplift of the Sierra Nevada Mountains beginning in the early Pliocene Epoch approximately 5 million years ago has been most pronounced in the southern Sierra with lesser uplift and tilt taking place in the Yuba and Feather River Basins. Much of the ancestral Sierra rock remains exposed in the Feather, where the Western Metamorphic Belt widens in comparison with the central and southern Sierra. As a result of the lesser uplift, the Feather River cuts through the Sierra Crest. The west facing slopes are less sharply tilted into the Sacramento Valley, and as a result, much of the topographic complexity associated with the older Eocene-age drainage patterns remain. The Sierra south of the Feather River Basin is positioned such that winter storm fronts, which move eastward across the Central Valley encounter the relatively steep Sierra mostly at right angles to its west facing slopes causing orographic and adiabatic cooling through air mass expansion. As the air cools, it loses its capacity to hold moisture and the saturated air delivers precipitation, mostly in the form of snowfall to the higher slopes of the Sierra. The Feather River above Lake Oroville however has a somewhat complex topography characterized by a mixed arrangement of ridges and valleys, much more indicative of the older erosion surfaces,

Paper presented Western Snow Conference 2011

[1] Operations and Maintenance, Power Generation Department, PG&E, Mail Code N11B, P.O. Box 770000, San Francisco, CA 94177, gjf2@pge.com

some which benefit immensely from orographic uplift and others that are sufficiently blocked by ridges to be considered as rain-shadowed subbasins. On the NFFR, air ascends upward and cross es the first westward facing ridges, losing much of its moisture, and quickly heats adiabatically as it compresses and descends into the various valleys such as at Lake Almanor (formally Big Meadows) and into the Indian and Genesee Valleys on the EBNFFR. As the flow of storm air crosses these valleys, the air mass warms sufficiently to hold much of its remaining moisture during its continued journey eastward. Consequently these valley areas, which are topographically blocked by ridges and various mountain peaks tend to be much warmer and drier than the Basin's other subbasin drainages. Snowpack accumulation for the west facing windward slopes and the canyon walls below Belden does not appear to have declined significantly (Freeman, 2010). The snow pack has shifted a portion of its melt regime from April into March, an effect of climate warming that seems to be increasingly becoming the norm for nearly all parts of the Sierra.

Both the 1,272 km^2 (491 mi^2) Lake Almanor subbasin and the 2,655 km^2 (1,025 mi^2) EBNFFR water year runoff started declining about 1960. Other subbasins such as Butt Valley, Bucks Creek, Grizzly, and the Feather River Canyon downstream of Canyon Dam and its confluence with the EBNFFR near Rich Bar are relatively high precipitation areas that have experienced relatively little change in both water year runoff and winter snowpack. These areas are characterized by windward facing slopes that cause the air to adiabatically rise, expand, and cool creating an increase in precipitation and snowfall due to loss in moisture holding capacity. While low elevation snowfall seems to be decreasing throughout northern California (Freeman, 2003, 2009), Freeman (2008, 2010) describes the Feather River as being relatively sensitive to the effects of climate change due to its relatively low elevation complex topography that includes some rain-shadowed subbasins. However, more recent study by Freeman, which is presented in this paper, indicates that rain-shadowed subbasins in northern CA are especially sensitive to climate change impacts characterized by changed hydrological pathways and water balances that include reduced aquifer outflow of springs, decreased runoff from snow melt, increased evapotranspiration, and for some topographically blocked subbasins, reduced water year runoff. With the conclusion that precipitation amounts have not significantly changed, and that a decline in aquifer outflow from springs has occurred, it seems likely that evapotranspiration has increased possibly as a result of both increased forest growth and increased fire suppression in recent years. Early 20th century pictures of the forest on the EBNFFR (Gruell, 2001) show a less dense forest than is currently observed. A less dense conifer distribution would have less evapotranspiration and

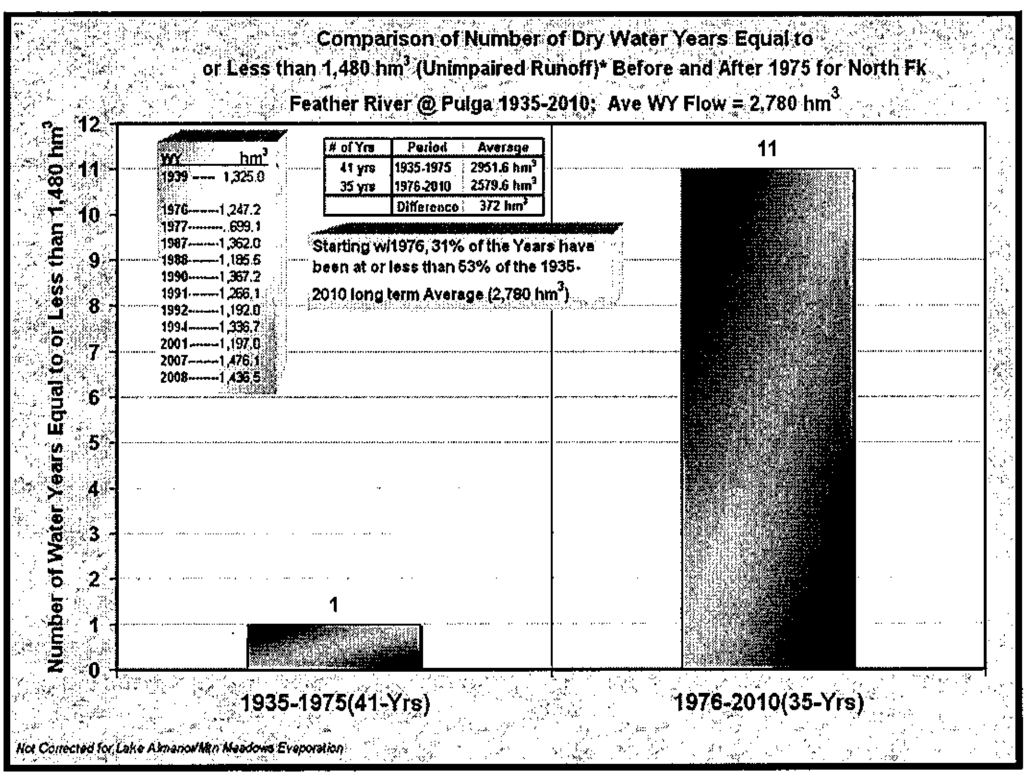


Figure 1. A comparison of the number of low flow water years for two different periods on the NFFR.

likely produce greater runoff compared with the current thicker conifer density. In recent years, runoff for a given amount of precipitation is most reduced in those years that are on the dry side. This observation appears to indicate that if soil moisture availability is limited, then runoff is further reduced as plant transpiration continues its demand on available soil moisture at and above the wilting point. Runoff is likely diminished in inverse proportion to increased evapotranspiration that is used in part to support leaf cooling and increased forest growth. Figure 1 illustrates that compared with prior years; starting in 1976 there is an increased frequency of low flow years for the NFFR @ Pulga. The NFFR @ Pulga collectively includes all upstream subbasins. In spite of the number of years for the more recent period being less following the 1935-1975 period, there are 11 times the number of years, which are less than 53% of the long term mean. This is consistent with the increased shift in the water balance from runoff to evapotranspiration. Groundwater for the Lake Almanor subbasin has continuously decreased in recent years. The springs for this subbasin consist primarily of relatively shallow porous volcanic basalts. Their depletion long term indicates susceptibility for drought imposed flow reduction. Prior to about 1970, aquifer outflow in the form of springs into and under the Lake accounted for more than 50% of the water year flow in average water years. Today that drought resistant reserve has become significantly reduced and accounts for less than 40% of the water year flow. Similar declines in outflow from springs have been found on the McKenzie River near Eugene, Oregon (Jefferson et al., 2008). Figures 2 and 3 illustrate the decline in aquifer outflow currently being observed for the Lake Almanor subbasin. An indexed approach, being used at PG&E, utilizes fall base flows to track and monitor aquifer outflow in a consistent manner. Once depleted to a low rate of outflow, it may take multiple years of wetness to restore the aquifers to their former storage levels. The springs under Lake Almanor are mostly the result of porous volcanic lava flows north and northeast of the Lake that encounter the harder, relatively impervious metasedimentary rocks of the Sierra block The loss of low elevation snowfall may have also decreased the rate of aquifer recharge opportunity from snowmelt. The relatively slow release of water from the snowpack typically creates an ideal opportunity for groundwater recharge. During wetter than normal precipitation years when soil moisture recharge is not limited from precipitation or snowpack amount, recharge opportunity is maximized and can satisfy all evapotranspiration demands as well as provide a directly proportional increase of runoff from each centimeter of precipitation added. Contributing factors to increased forest growth likely include warmer temperatures, increases in carbon dioxide, and fire suppression in recent years. If vegetation is not moisture stressed, then the increase in carbon dioxide that accompanies climate change may possibly be accelerating forest growth, utilizing increased amounts of water, which in prior years was available for surface

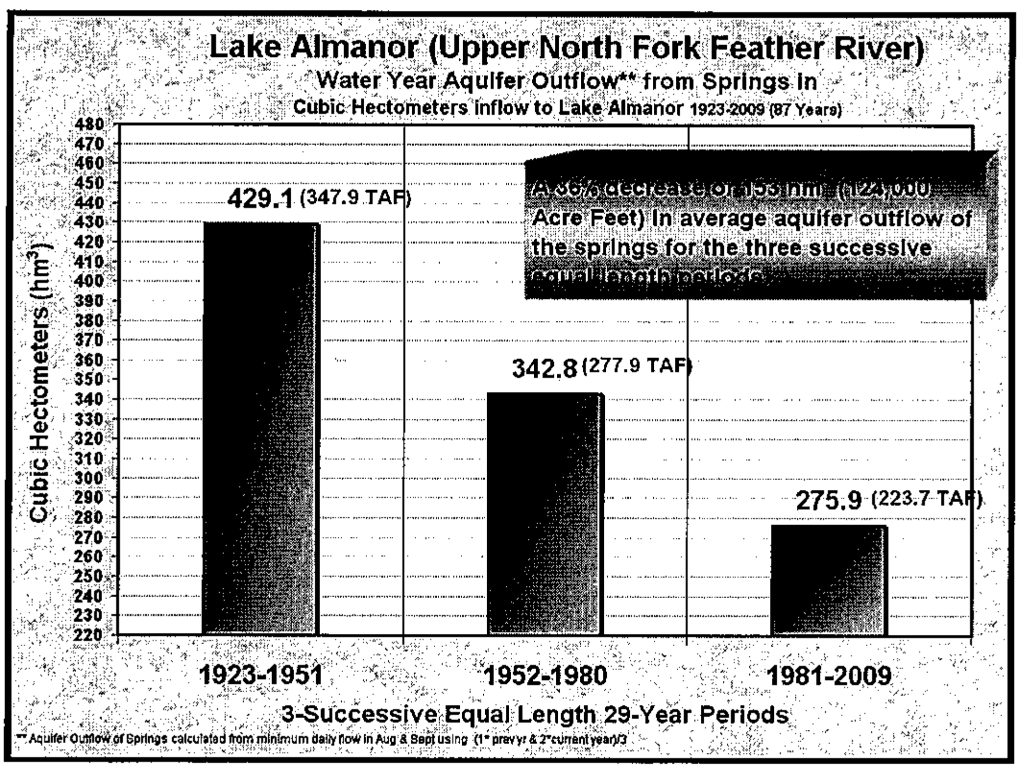


Figure 2. The long term decline in aquifer outflow of springs into Lake Almanor.

runoff. Today much of that water,w hich has in recent years become increasingly used to satisfy evapotranspiration is neither replenishing the aquifers nor running off as surface flow. The physiographic controls on how the Feather

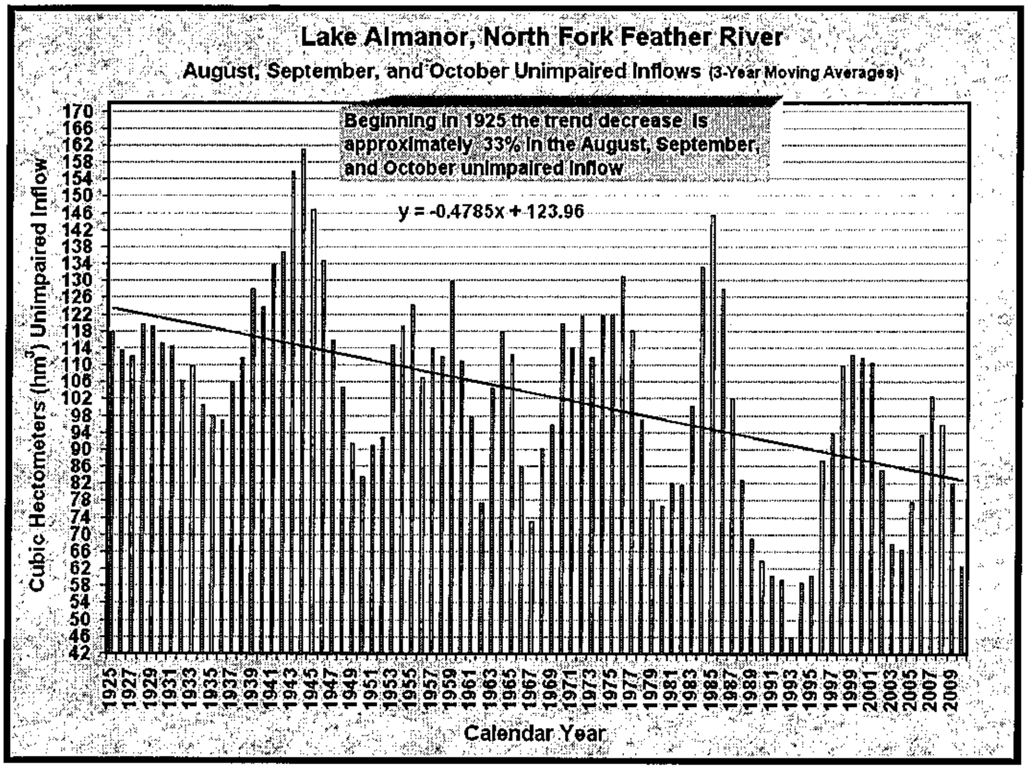


Figure 3. Summer and fall unimpaired inflows to Lake Almanor have declined approximately 33% (trended change) since 1925.

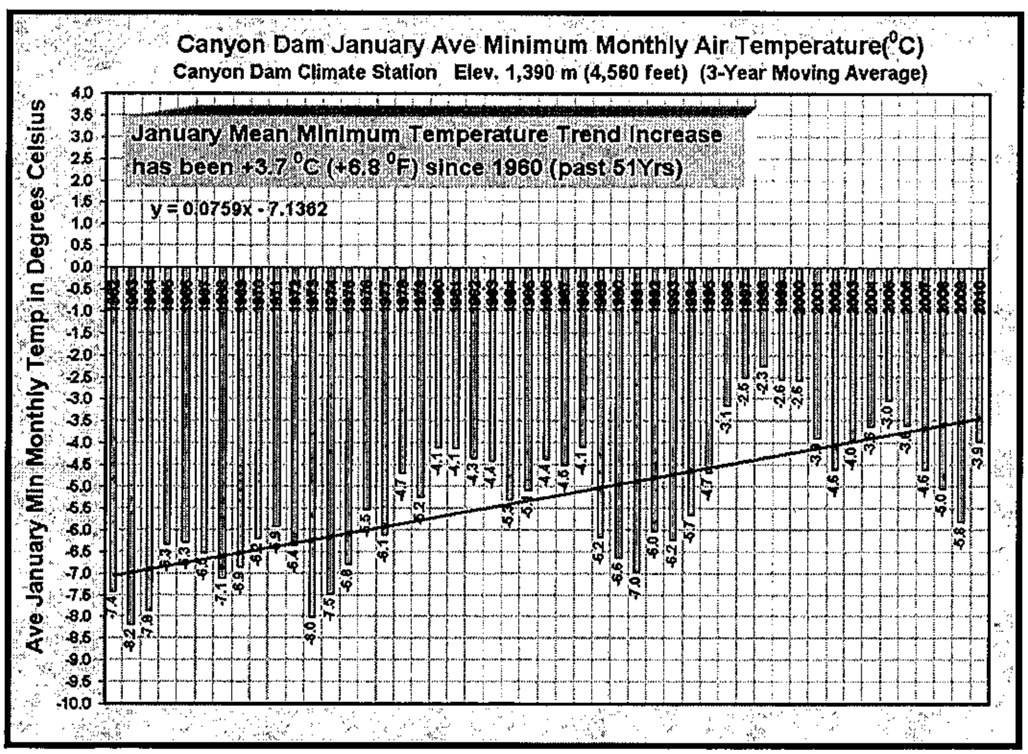


Figure 4. Increase in the mean minimum January temperature at Canyon Dam.

River's vegetation including the forests respond to change in energy and water flux mostly in the form of increased warming and soil moisture stress are not well understood. At this time there is a scarcity of ground based instrumentation with sufficient good quality record to fully understand what is taking place.

Minimum January temperatures were analyzed at existing climate stations on the Feather River. Minimum January trended temperatures were an average of 5.1^{0}C (9.2^{0}F) degrees warmer at Quincy on the EBNFFR, 3.8^{0}C (6.8^{0}F) degrees warmer for Canyon Dam, and 2.8^{0}C (5.0^{0}F) degrees warmer at Chester since the early 1960's. This is 2-4 times the increase observed for most mountain locations elsewhere in the Sierra to the south. Figure 4 is an example of data charted for the Canyon Dam climate station. The minimum temperature at the nearby Prattville climate station showed a similar increase. While there is only a limited number of climate stations in the area, the much warmer winter temperatures, loss of snowpack, and decrease in annual runoff appear supportive that the hydrology is changing for at least the two of the subbasins, EBNFFR and Lake Almanor on the upper NFFR.

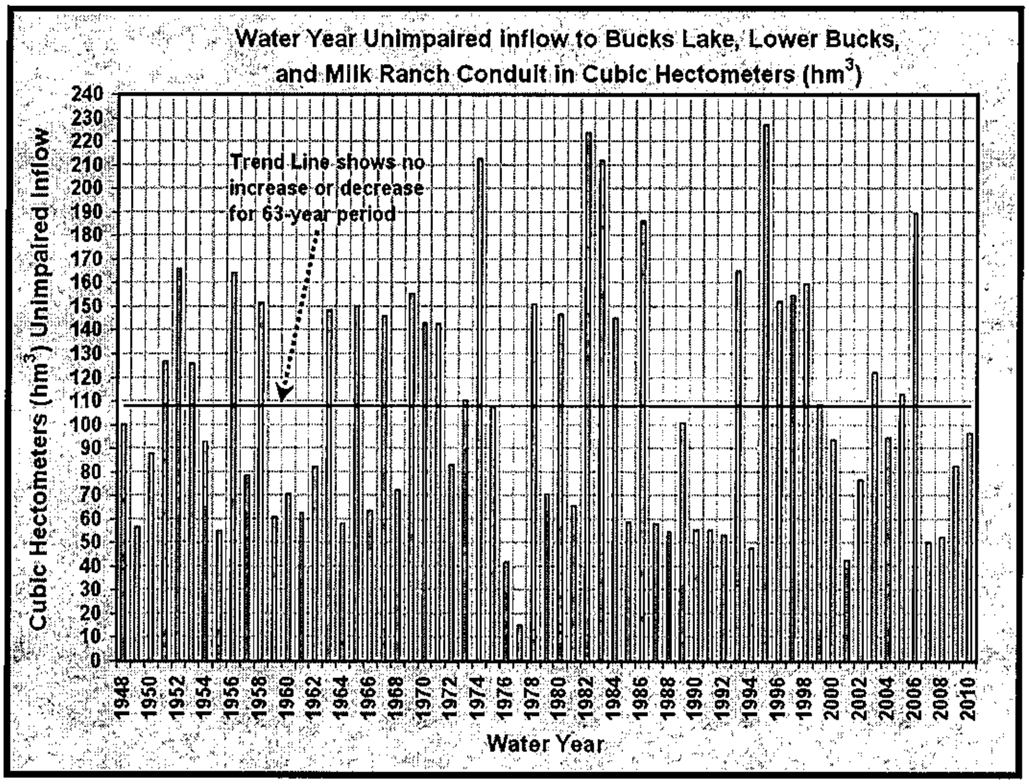


Figure 5. The Bucks Lake Subbasin is characterized by strong orographic cooling.

The Bucks Lake and Lower Bucks Diversion subbasin exhibits strong orographically caused precipitation increases during storm systems. The water year runoff shown in Figure 5 reveals very little change for water year runoff quantity from the warming climate. The Bucks Lake low elevation snowpack has mostly remained unchanged historically, but with warmer air having the capacity to hold more water, annual precipitation amount in the future could potentially increase for these types of windward facing subbasins that are orographically cooled (Freeman, 2010). The warming climate's impact on areas with very strong orographic cooling has the overall potential to increase precipitation and snowfall for isolated peaks such as at Mt. Shasta and Mt. Lassen (Freeman, 2010; Howat, et al., 2007) and also for the higher elevations in the southern Sierra (Howat and Tulaczyk, 2005).

WARMER STORMS IN RECENT YEARS

A comparison of average daily minimum storm temperatures from the Canyon Dam climate station as shown in Figure 6 for days with precipitation for two successive 34-year periods shows an average 1.4 ^{0}C (2.5^{0}F) increase for the more recent January through March period. This increase supports the decrease in low elevation snowpack being observed for snow courses on the Feather River such as for the Mt. Stover snow course at the 1,646 m

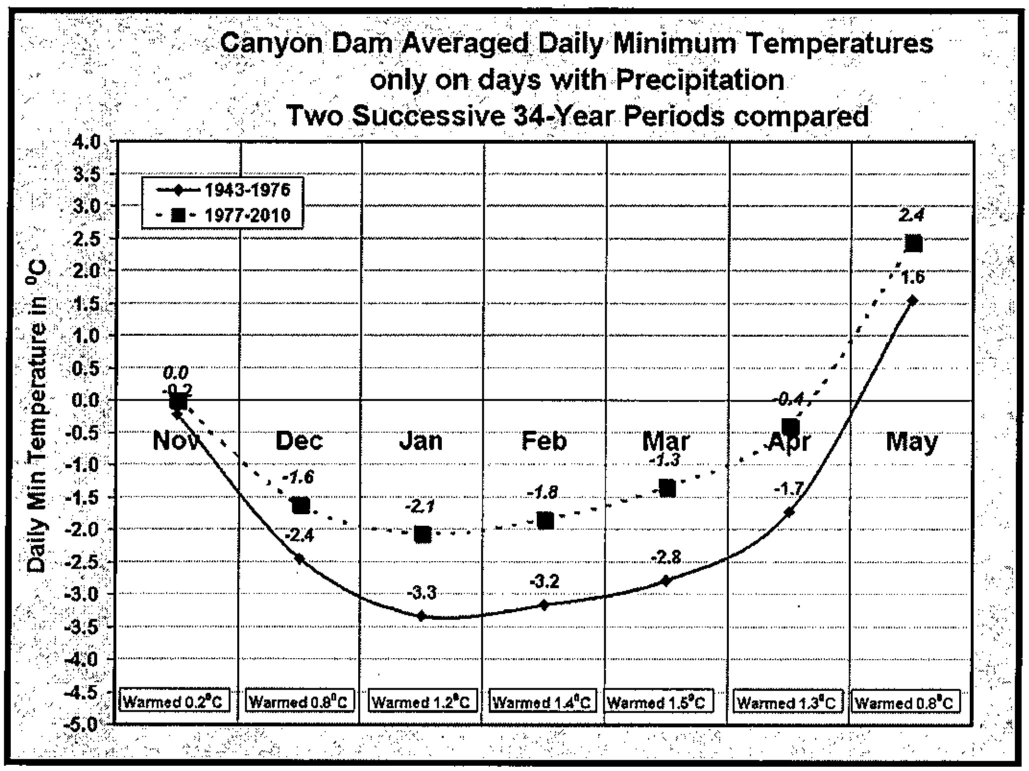


Figure 6. Canyon Dam averaged daily minimum temperatures only on days with precipitation for two successive 34-year periods.

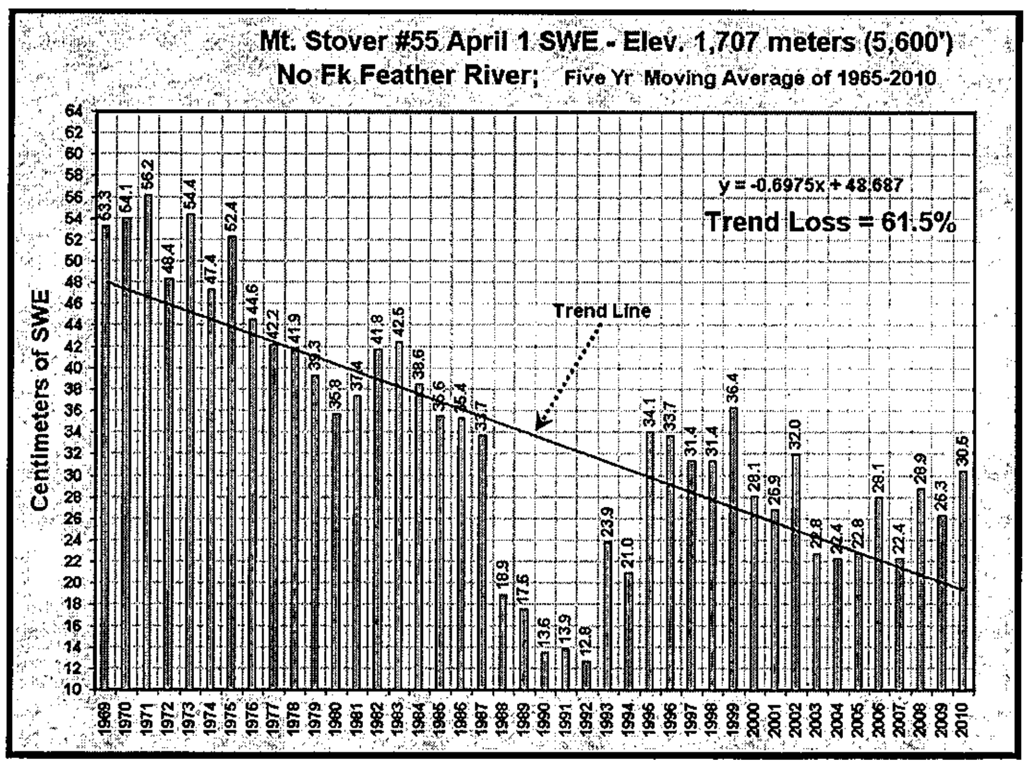


Figure 7. A 5-year moving average for the April 1 snow water equivalent at the Mt. Stover snow course on the Lake Almanor subbasin. The trend loss is almost 63%.

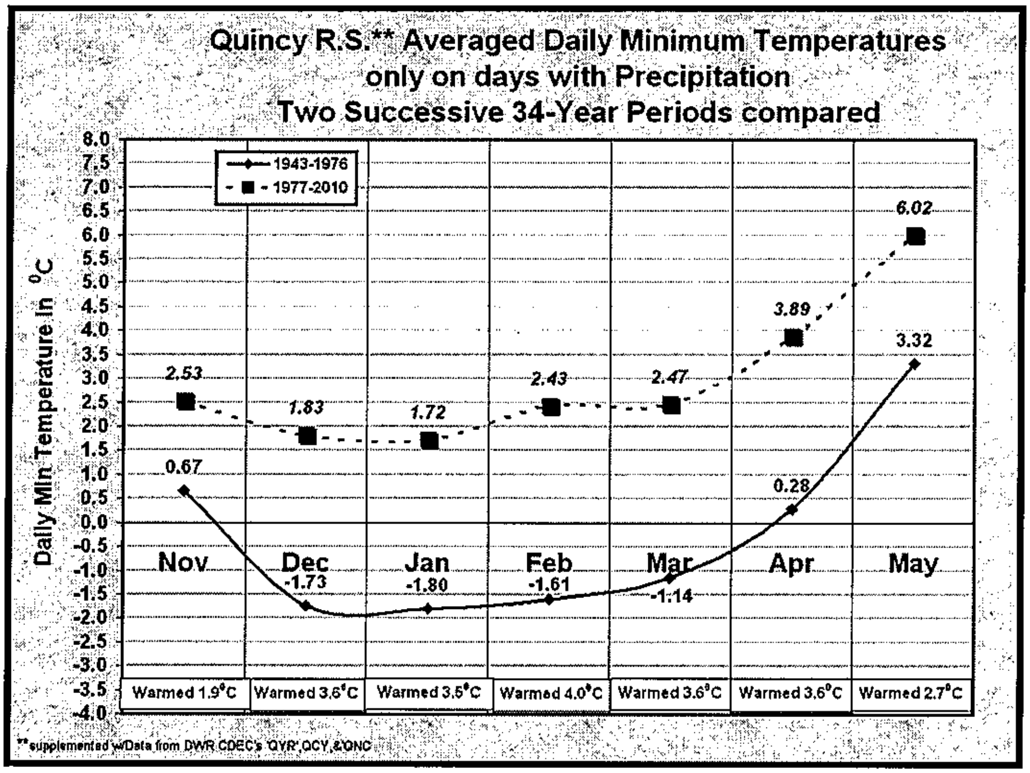


Figure 8. Quincy Ranger Station's averaged daily minimum temperatures only on days with precipitation for two successive 34-year periods.

(5,600 ft) elevation (Figure 7). The reduced April 1 snow water equivalent appears consistent with both less snowfall in recent years and an earlier snowmelt with increased runoff that now occurs in the month of March. Because such a large portion of the Lake Almanor subbasin is below the 1,646 m (5,600 ft) elevation, a large proportion of the watershed's snowpack no longer exists in most years. The loss of mountain snowpack observed for the NFFR is consistent with findings by others (Stewart, 2009, Pierce, et al., 2008). The loss of the low elevation snowpack may likely be limiting groundwater recharge. However, reduced aquifer outflow also seems to have partly been the result of increased evapotranspiration taking place on the subbasin. Regardless of the long term trend, it should be kept in mind that even with a strong trend, individual year variation can result in an occasional year having a large April 1 snowpack such as occurred in 2010 when the April 1 SWE at Mt. Stover was 49.0 cm (19.3 in) and 131% of the 1951-2000 50-yr average of 37.3 cm (14.7 in). Trends and moving averages are simply the smoothed over statistic of the individual years with their included variance. Figure 8 shows a similar, but more significant increase in minimum temperature accompanying storms in the more recent 34-year period at the Quincy R.S. climate station, which was used to represent the rain-shadowed EBNFFR. The implications of warmer winter minimum temperatures accompanied by increasing snow loss from the low elevation snow zone could result in earlier drying of soils. Rainfall typically diminishes after April. This and the loss of the low elevation snowpack that typically provides spring and early summer soil moisture recharge from snowmelt may lead to earlier soil moisture loss. Warmer temperatures in recent years would support increased forest growth and the depletion of remaining soil moisture. The increased soil moisture demand on soils may explain some of the loss of aquifer outflow from the springs. The early spring loss of the thinning snowpack is also likely to lead to increased surface heating from loss of albedo. This has potential to cause increased soil warming and evapotranspiration.

THE IMPORTANCE OF OROGRAPHIC COOLING WITH A WARMING CLIMATE

For most of the Sierra Nevada Mountains, the west side slope is conducive to orographic cooling almost up to the summit. The Feather River in the northern end of the Sierra, however, has not been tilted or pushed upward from Basin and Range crustal extension nearly as much compared with the southern Sierra, such as west of the Owens Valley, which has been lifted more than 2,438 m (8,000 ft) in elevation. Much of the original ancestral

Sierra's metamorphic complexity remains as it did during the mid-Tertiary period. During winter storm fronts, if incoming air is not sufficiently cooled, the snowline rises. If air temperatures during storms continue to rise, there may eventually be a point in time where less water year precipitation occurs for the rain-shadowed subbasins on the Feather Basin. A minor loss appears to have already occurred in the Quincy area, but the data quality is insufficient to scientifically support making that conclusion. The water year runoff averages for those subbasins on the NFFR Basin which are strongly orographic influenced during storm fronts have remained essentially unchanged since the mid-1960's.

THE CHANGING WATER BALANCE

In terms of a mass balance, water year surface runoff equals water remaining from precipitation after evapotranspiration and infiltration is augmented by water flowing from soils and aquifers all for the same 12 month period. The water balance is reviewed in this section for both the rain-shadowed EBNFFR and for Lake Almanor. The Lake Almanor subbasin has considerable aquifer outflow from precipitation of past years that occurs from springs even during very dry years. In addition to the decrease in April through June runoff, the water year runoff for both subbasins has also declined since about the mid 1970's. Figure 9 illustrates this decline in water year runoff for the EBNFFR along with an estimate of increased evapotranspiration based on using the 1950-1970 20-year period as the zero base period. Assuming that the ground water storage has declined, the reduction in aquifer

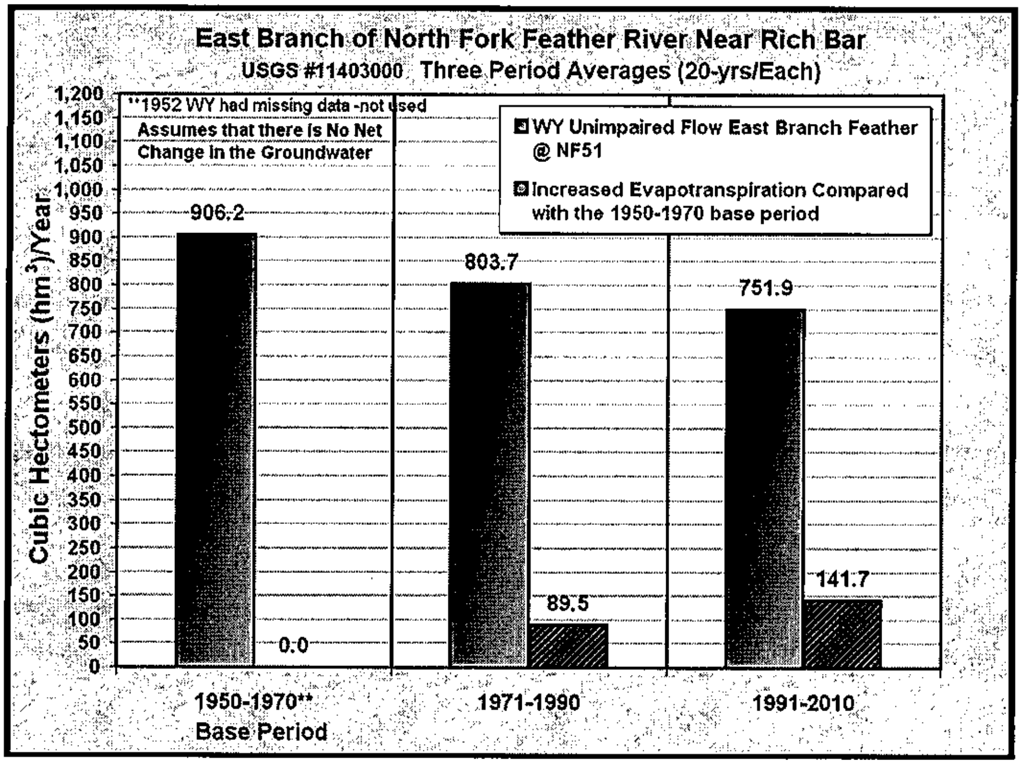


Figure 9. Three successive 20-year periods showing surface runoff decline for the EBNFFR near Rich Bar.

outflow may in part be due to lack of groundwater recharge opportunity. Snowmelt in the spring tends to occur at a sufficiently slow rate to provide maximum opportunity for infiltration and groundwater recharge. Since aquifer outflow has declined on the Lake Almanor subbasin, one needs to investigate the precipitation for the same period to verify that seasonal precipitation has not also declined. If the seasonal precipitation trend is stationary and the aquifer storage is declining as is indicated from aquifer outflow rates, then the evapotranspiration rate is likely increasing in direct proportion to the loss in runoff. The Quincy climate station has considerable missing precipitation record and for purpose of this analysis was considered poor quality. However, the Caribou Power House climate station, which is also partially rain-shadowed had reasonably good quality precipitation record and was utilized to compute the relative recovery factor decline for the three 20-year periods. This would also provide an indication of the period evapotranspiration increase for the two more recent periods. Figure 10 illustrates the three-period decline in runoff recovery factors that have taken place with the evapotranspiration increases in recent years. The Caribou PH climate station shows only a slight decrease in the successive period precipitation amounts

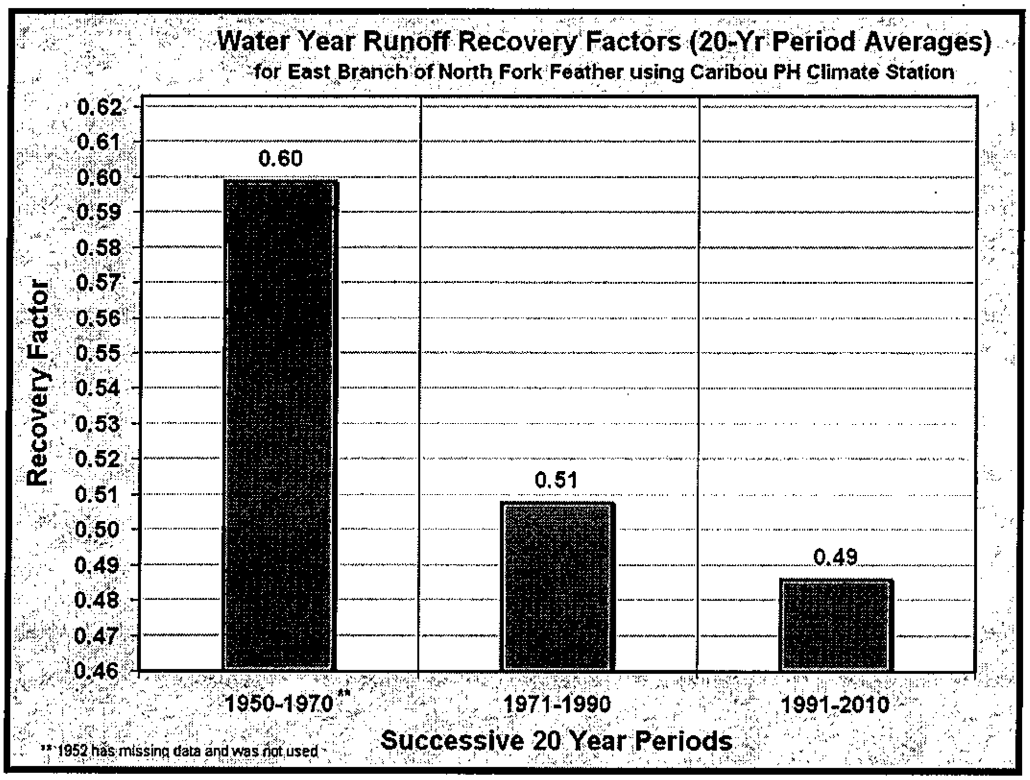


Figure 10. Runoff Recovery factors for the EBNFFR

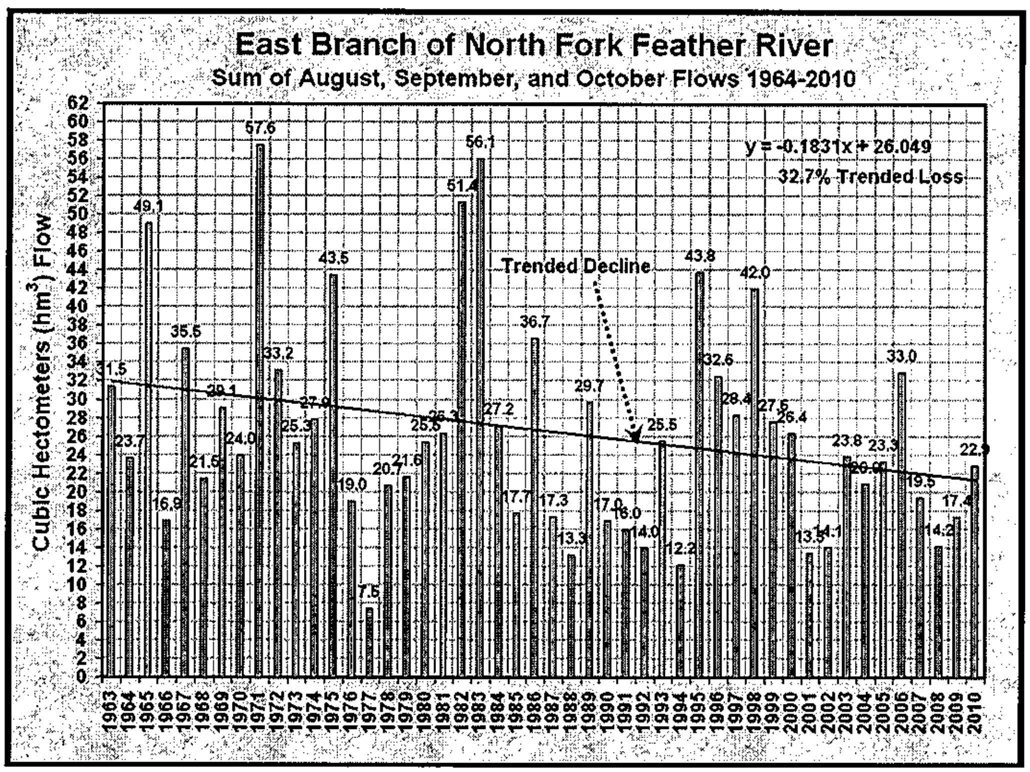


Figure 11. Decline in late summer and fall flows for the EBNFFR

Table 1. Recovery Factors for those water years on the EBNFFR that are 75% and 90% of normal (Caribou PH Climate Station).

Percent of 1950-2010 precipitation 61-Yr Average		90%	75%
Recovery Factor	1951-1980	0.40	0.35
Recovery Factor	1981-2010	0.33	0.30

during the three periods. Its decrease is essentially removed from the analysis by utilizing a single equation for computing the 3-period runoff recovery factor. Table 1 illustrates both a decrease in surface runoff recovery that takes place in the more recent period and also the decrease that occurs as precipitation decreases from 90% and less to 75% and less than normal. All of the recovery factors for below normal precipitation years are less than those for the most recent period of Figure 10. The general decrease in surface runoff recovery from water year precipitation likely results from the vegetation's moisture needs to support both its growth and increased need for evaporative cooling. Along with the reduced infiltration of water from the decline in low elevation snowmelt, the need for

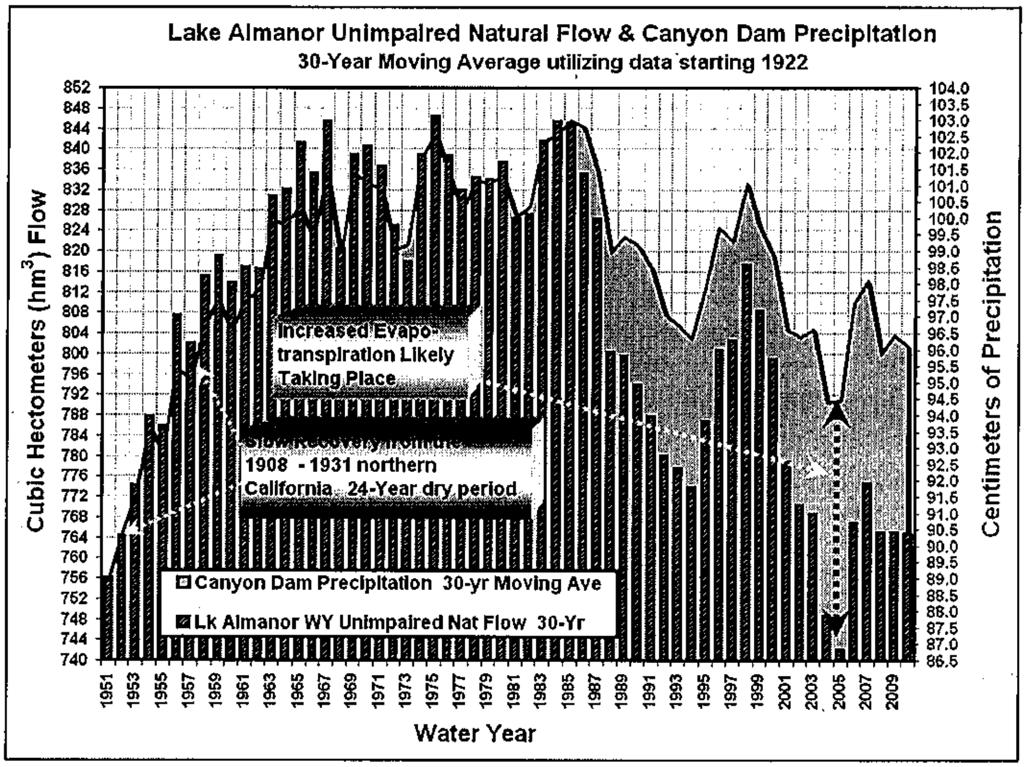


Figure 12. The Lake Almanor 30-year moving average of water year runoff plotted against the Canyon Dam 30-year moving average of water year precipitation.

vegetation to maintain a suitable Bowen Ratio by increased evapotranspiration also likely adds to the early summer soil moisture deficit and other losses that are taking place on the basin. While not volcanic like the headwaters above Lake Almanor, the soil moisture and ground water losses on the EBNFFR over the period of years since about the mid-1960's, can be seen in Figure 11. The decrease in the August through October late summer and fall flows is consistent with an overall decline in soil moisture and groundwater decline in the years since the mid-1960's. Utilizing long 30-year moving averages, Figure 12 utilizes data alignment through vertical axis scaling for the earlier years to illustrate this loss of surface runoff for equivalent quantities of precipitation that occurred in recent years. The long term averages utilized for Lake Almanor in Figure 12 also reveal the long term recovery that took place on northern California watersheds following the 1908 through 1931 'dry period' (Freeman, 2001).

USE OF TRENDED HISTORICAL DATA TO DETECT AND QUANTIFY CLIMATE CHANGE IMPACT AT THE SUBBASIN LEVEL

The decline in water year runoff, observed temperature increase, and significant low elevation snowpack decline in the observed data on rain-shadowed subbasins in northern California since the mid-1970's may not be consistent with the regional temperature increases that are currently being predicted by many of the most commonly used Global Climate Models (GCMs) and their associated scenarios. Actual data from the rain-shadowed subbasins on the NFFR and elsewhere in northern California indicate three and four times the warming that has occurred elsewhere in the Sierra on the larger regional basis. Utilizing the results of regional GCM models that may have not been corrected for topographic complexity and associated problems with high resolution spatial scaling may add large uncertainty, and may not be in alignment with the actual data currently being observed for these subbasins. Similar concerns with defining the effects of a warming climate on mountains with complex topography and its effect on orographic cooling and snowfall have been investigated in the Cascade Mountains near Mt. Rainier (Minder, 2010). The orographically influenced subbasins in the Feather River Canyon downstream of Belden and in the Bucks-Grizzly subbasin have a hydrological response to winter storms, which is more typical of much of the west facing tilted Sierra block to the south. They are characterized by strong orographic cooling during most winter storms, which appears to greatly moderate the effects of climate warming. Knowing that regardless of the hydrological modeling approach utilized to study and predict climate change, whether it be the lumped or the distributed hydrological response unit approach, if the temperature change assumptions are not sufficiently sensitive to relatively small topographic features that determine orographic cooling and compressional heating at the subbasin level of detail, then the hydrological extension and future assumptions may not be relevant. The Water Management Team at PG&E has sufficiently detailed unimpaired flows at the operational subbasin level of detail throughout the Sierra and southern Cascades to compare and identify trends now taking place at the relatively small subbasin level of detail. At PG&E isohyetal maps are utilized as an initial tool for quickly locating rain-shadowed subbasins that may have potential to be negatively impacted by water year flow decline from climate change. Analysis of monthly and seasonal historical data then follows to evaluate the extent of subbasin impact (Freeman, 2010). If the GCM modeling technology along with downscaling methodology eventually proves relevant, aligned with, and reflective of actual historical data for these rain-shadowed subbasins, then use of GCM output for predicting hydrological water balance changes at the subbasin level would have increased value for operational hydroelectric planning. At this time, utilizing simple extension of the observed data trends such as are being made for rain-shadowed subbasins on the NFFR may be the simplest and most meaningful approach to identifying short term future impacts of warming.

SUMMARY AND CONCLUSIONS

Two rain-shadowed subbasins on the NFFR, Lake Almanor and EBNFFR, were found to not only have less April through June Runoff in recent years, but they are also losing water year runoff as well. Minimum average temperatures have increased for both of these subbasins and the minimum temperatures for days with precipitation have also increased. Increased air temperatures accompanied by a significant decline in low elevation snowpack have likely led to less available soil moisture for surface runoff. Forest vegetation appears to be doing well and appears to have increased in biomass since the mid-1970's. Increased evapotranspiration appears to be the most likely reason for the decline in water year runoff. The Lake Almanor subbasin has also lost aquifer outflow as evidenced in a decline of late summer and fall base flows. The opportunity for soil moisture recharge appears to have declined with the loss of low elevation snowpack. As summer soil moisture has become increasingly limited since the mid-1970's, forest vegetation appears to be satisfying its soil moisture needs to meet potential evapotranspiration at the expense of declining streamflow. Warmer air temperatures during the active growing season have likely resulted in increased evapotranspiration needed to meet leaf cooling and maintain growth. Both the EBNFFR and the Lake Almanor subbasin have shown significant late summer and fall runoff declines since the mid 1970's. Recovery factors of water year runoff from precipitation have declined the most during years with below average precipitation. These are years when actual evapotranspiration may be less than potential evapotranspiration. Subbasins such as the combined Bucks Lake and Grizzly drainage area as well as the Feather River Canyon Area below the confluence of the EBNFFR with the NFFR near Belden Powerhouse are strongly orographic with frontal systems typically being cooled and receiving normal snowfall. These areas do not seem to show any decline in water year runoff, however the March runoff has increased since the mid-1970's, indicating the same earlier snowmelt as is observed for most mountain locations in the Sierra. For the NFFR as a whole, there is

11 times the number of water years with runoff below 1,480 hm^3 (1,200 TAF)/water year since the mid 1970's compared with the preceding period of equal length.

REFERENCES

Freeman, G. J. 2001. The impacts of current and past climate on Pacific Gas & Electric's 2001 hydroelectric outlook. PACLIM, 2001. pp. 21-37.

Freeman, G. J. 2003. Climate change and California's diminishing low elevation snowpack – a hydroelectric scheduling perspective. Western Snow Conference 71: 39-47.

Freeman, G. J. 2008. Runoff impacts of climate change on northern California's watersheds as influenced by geology and elevation-a mountain hydroelectric system perspective. Western Snow Conference 76: 23-34.

Freeman, G. J. 2009. Diminishing snowfall in central and northern California's mixed rain and snow elevation zone. Western Snow Conference 77: 25-35.

Freeman, G. J. 2010. Tracking the impact of climate change on central and northern California's spring snowmelt subbasin runoff. Western Snow Conference 78: 107-118.

Gruell, G. E. 2001. Fire in Sierra Nevada Forests: A Photographic Interpretation of Ecological Change since 1849. Mountain Press. pp. 98-101.

Howat, I.M., S. Tulaczyk. 2005. Trends in spring snowpack over a half-century of climate warming in California, USA. Annals of Glaciology, volume 40:151-156.

Howat, I. M., S. Tulaczk, P. Rhodes, K. Israel, M. Snyder. 2007. A precipitation-dominated, mid-latitude glacier system: Mount Shasta California. Climate Dynamics, 28: 85-98.

Jefferson, A., A. Nolin, S. Lewis, and C. Tague. 2008. Hydrogeologic controls on streamflow sensitivity to climate variation, Hydrological Processes, 22: 4371–4385.

Minder, J. 2010. The sensitivity of mountain snowpack augmentation to climate warming. Journal of Climate, American Meteorological Society. 23: 2634-2650.

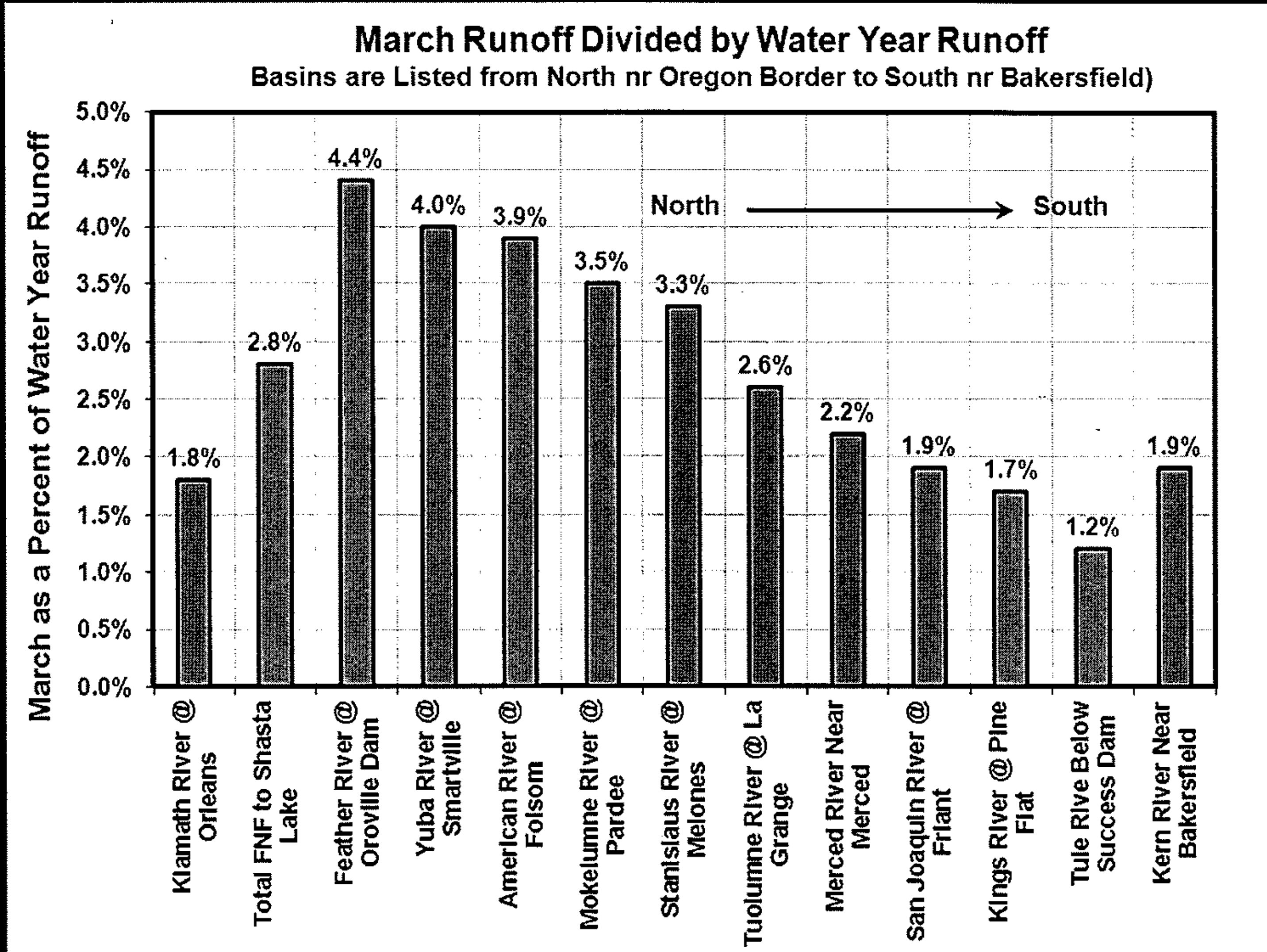
Pierce, D.W., T.P. Barnett, H.G. Hidalgo, T. Das, C. Bonfilis, B.D. Santer, G. Bala, M.D. Dettinger, D. R. Cayan, A Mirin, A. W. Wood, and T. Nozawa. 2008. Attribution of Declining Western U.S. Snowpack to Human Effects. Journal of Climate, American Meteorological Society. 21: 6425-6444.

Stewart, I. T. 2009. Changes in snowpack and snowmelt runoff for key mountain regions. Hydrological Processes. 23: 78-94.

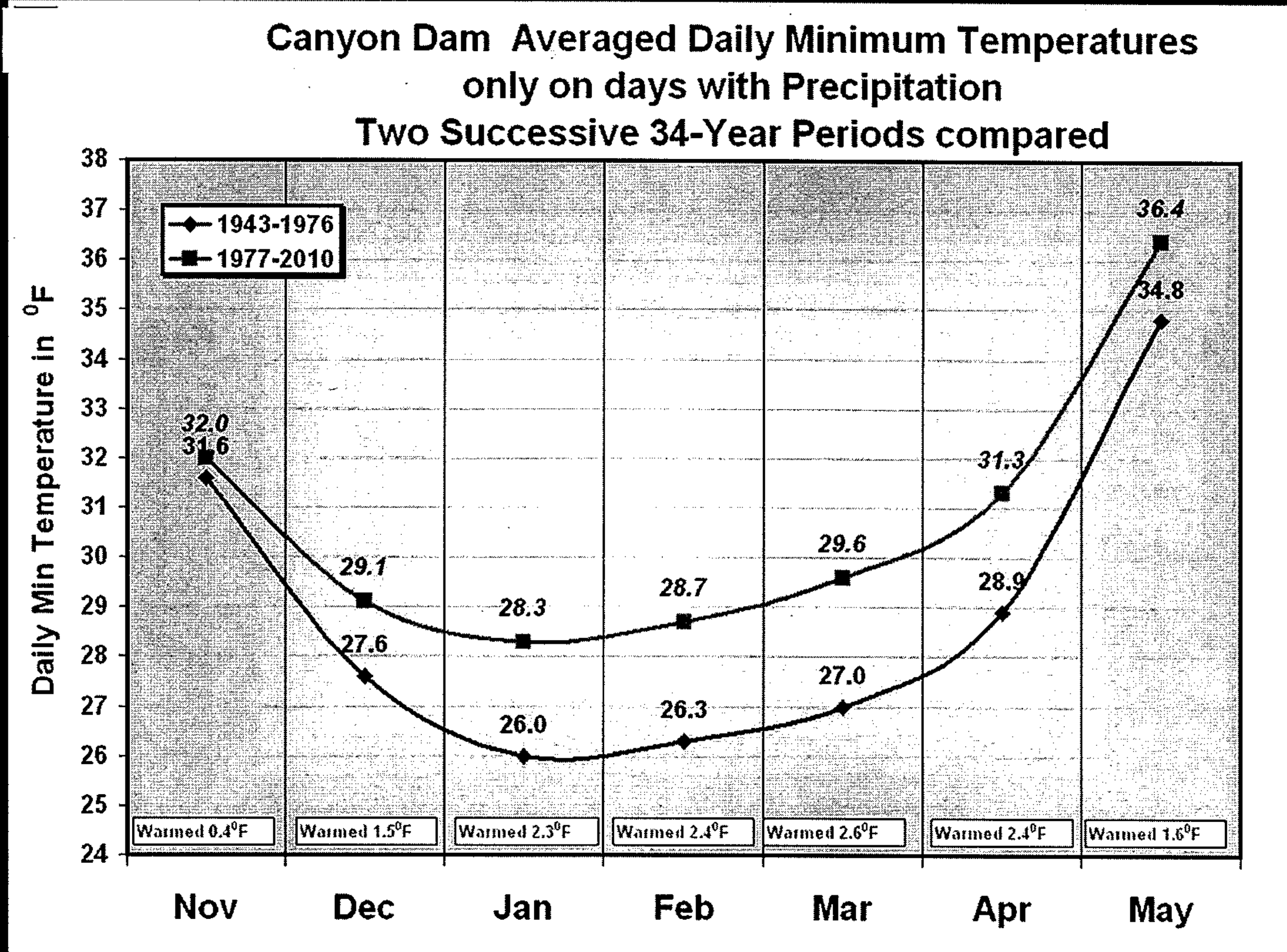
Some Hydrometeorological Effects of Climate Change for the North Fork Feather River Headwater Drainage with Focus on the Lake Almanor and the East Branch Subbasins

May 6, 2014

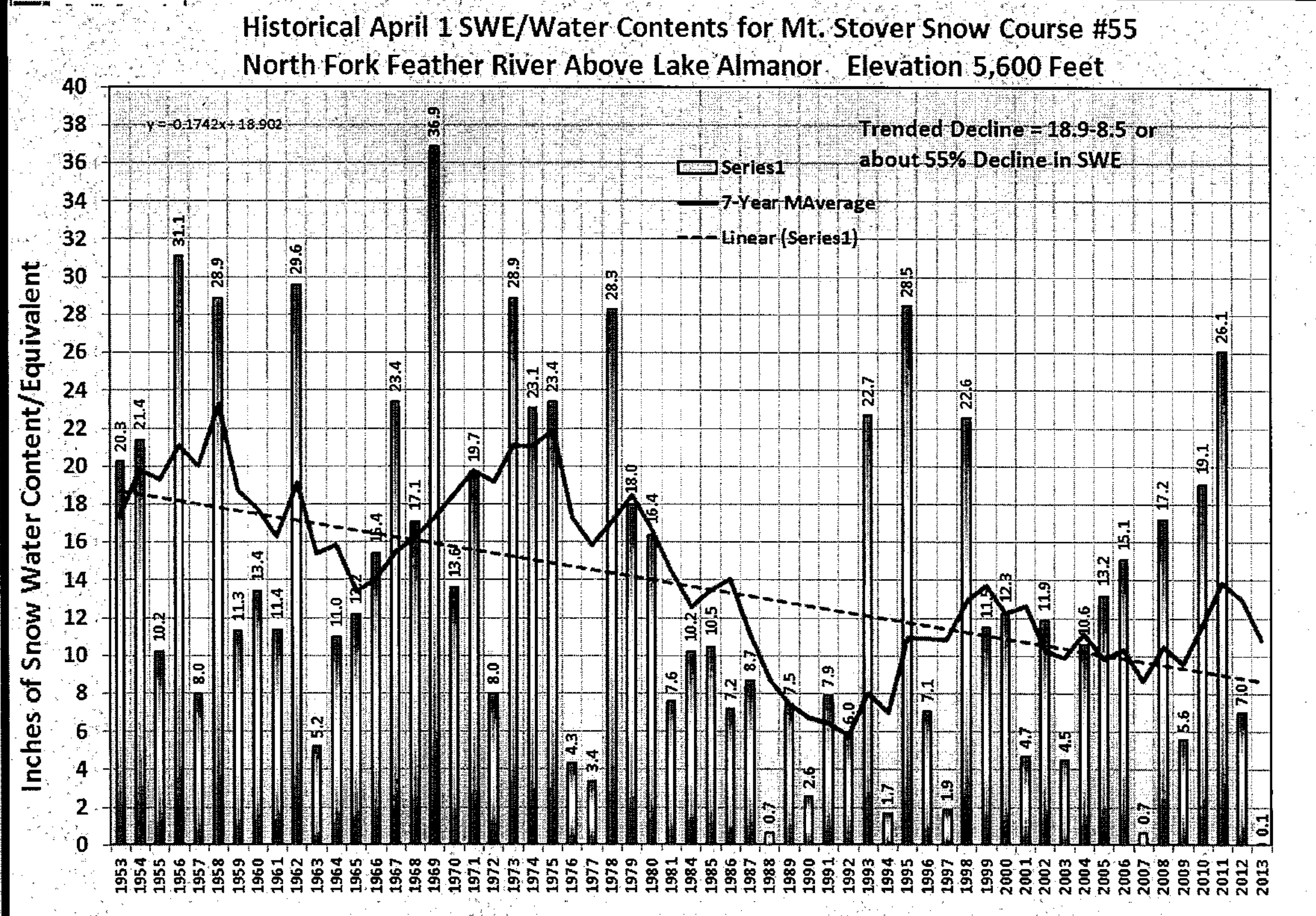
Compared Statewide an Analysis of Snowmelt Runoff Shows the Feather River to Have the Largest Shift towards an Earlier Snowmelt in March



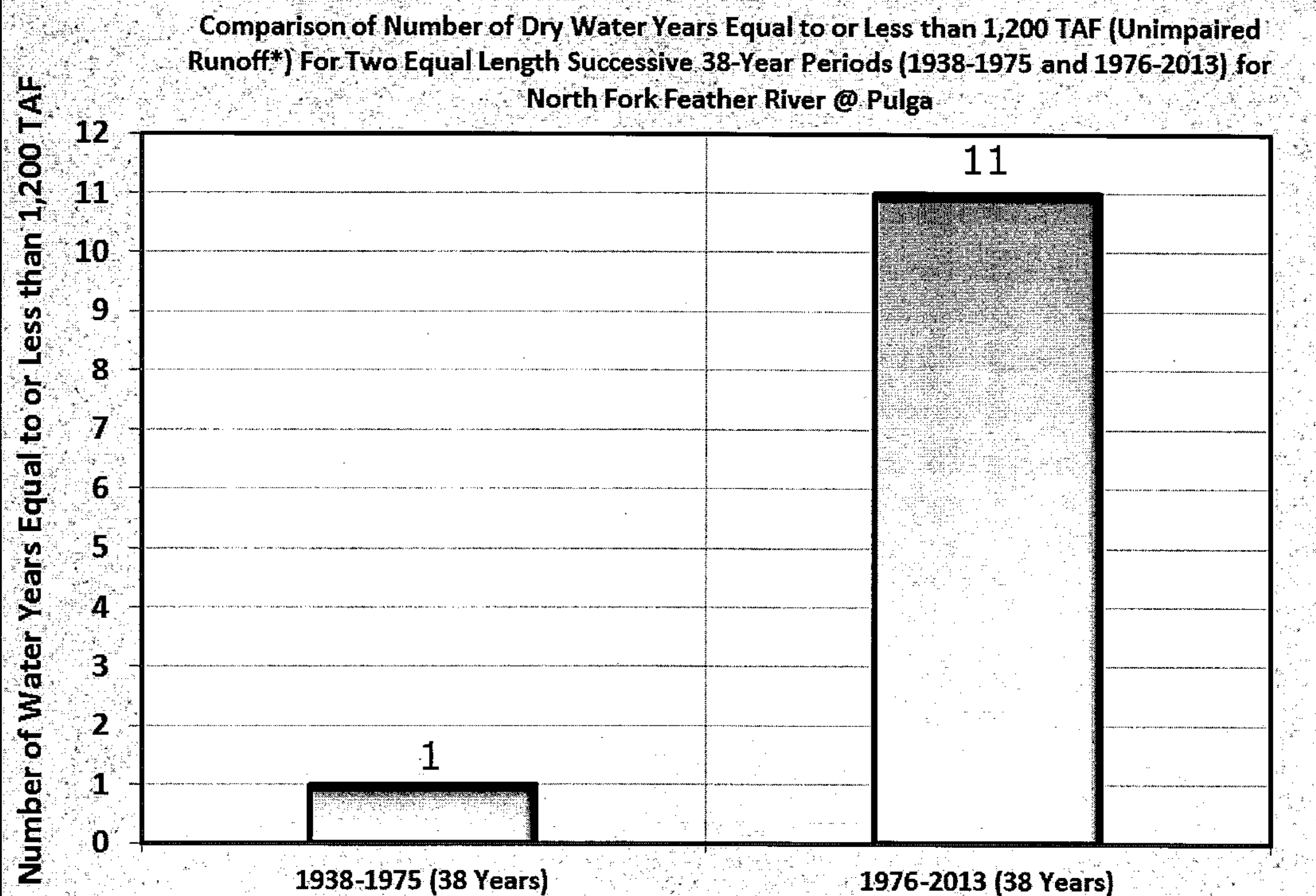
Storms are Warmer in Recent Years Bringing Rainfall to Higher Elevations Compared with Years Prior to mid -1970's



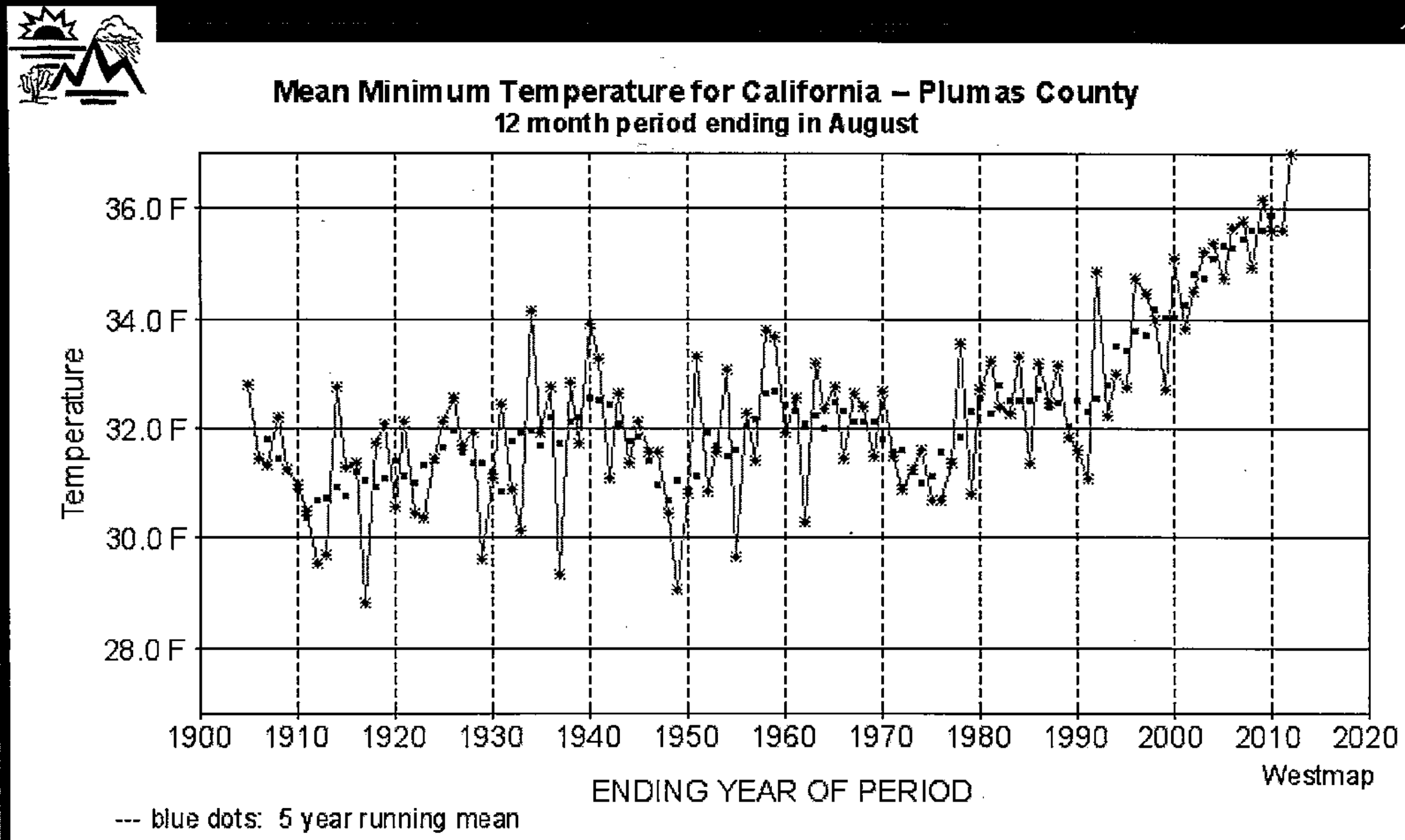
An Example of a Trending Decline In Lake Almanor's Snowpack



Recent Years Reveal an Increase in Number of Dry Water Years for North Fork Feather River



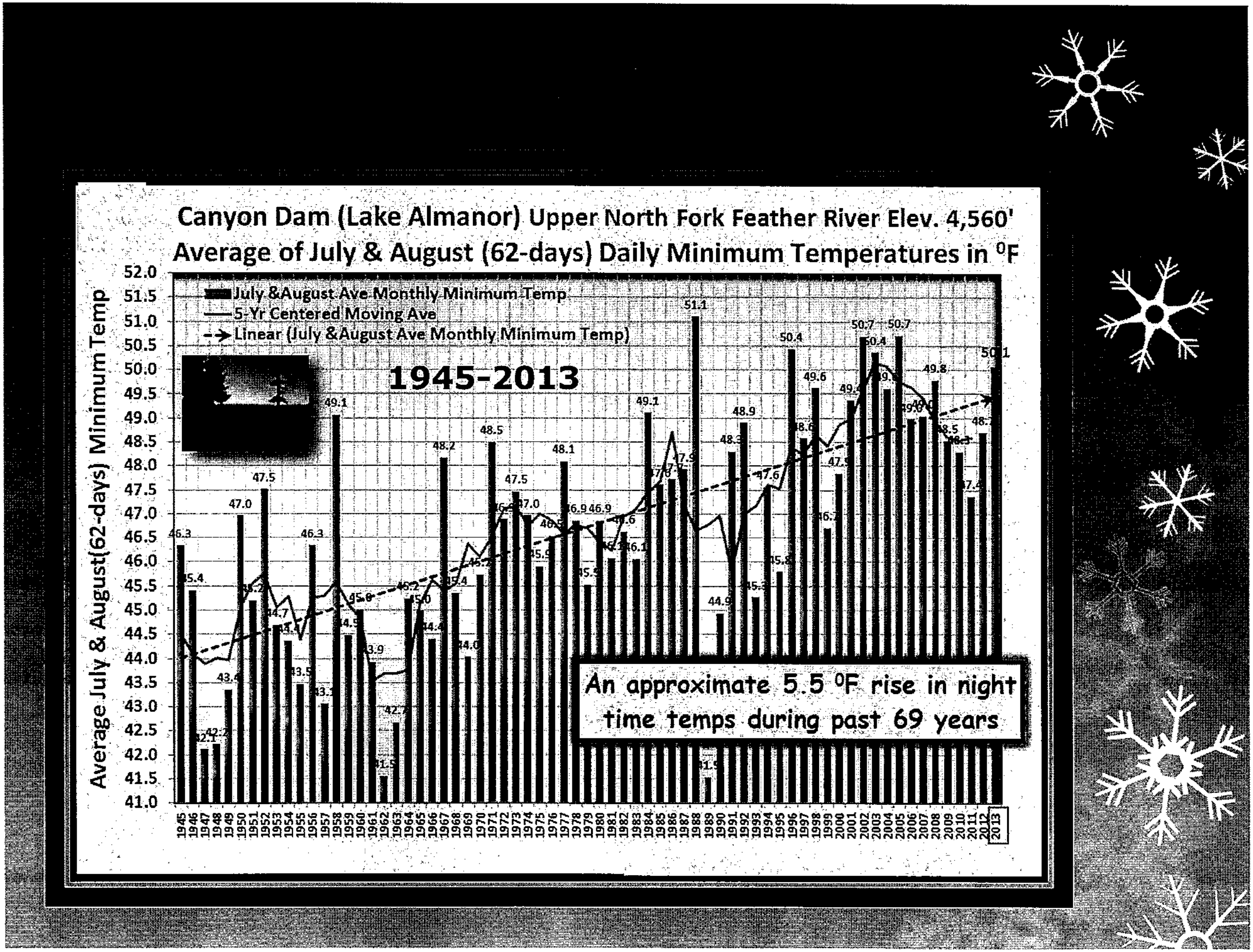
*Not corrected for Lake Almanor or Mtn Meadows surface evaporation



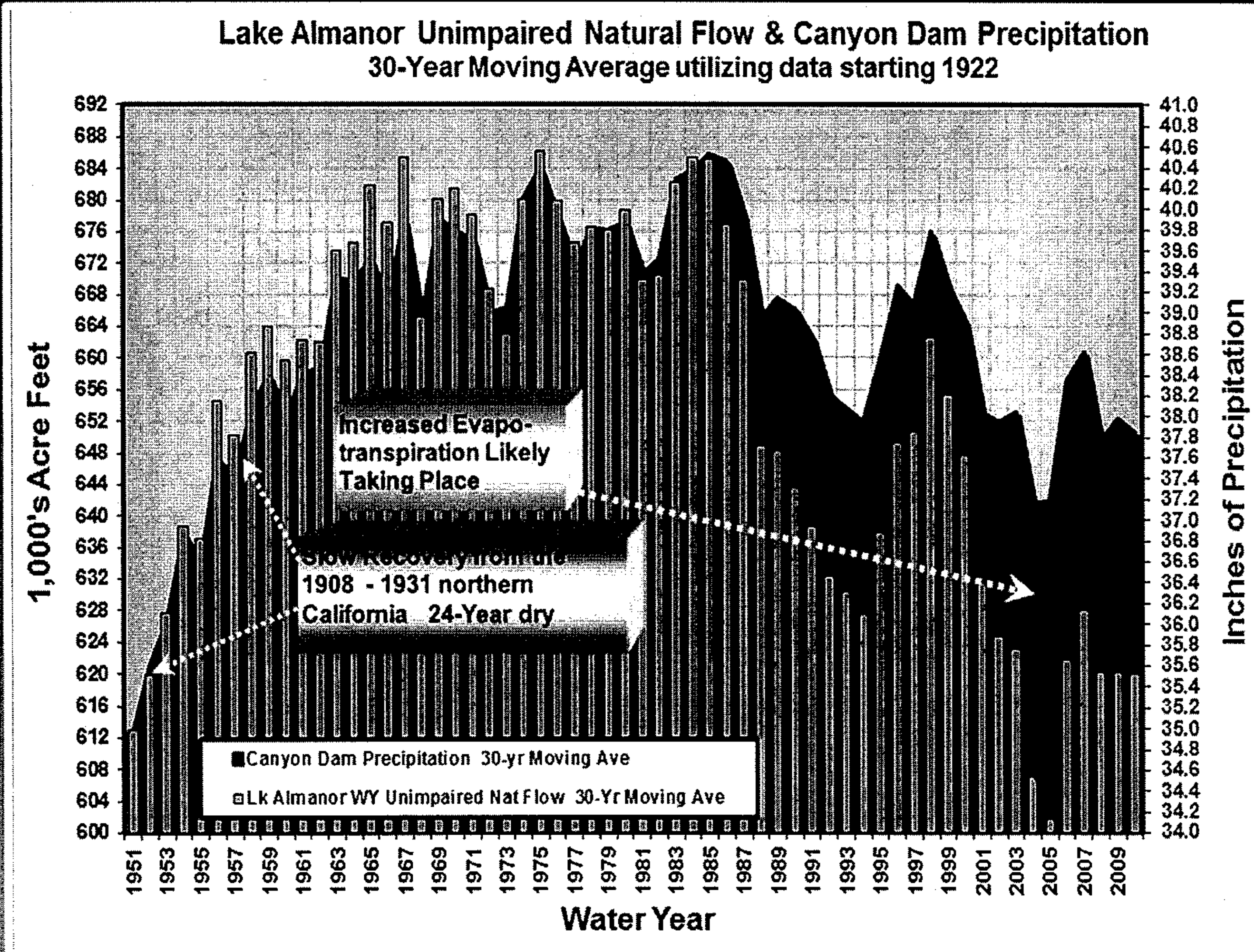
1990	31.6
1991	31.1
1992	34.9
1993	32.3
1994	33.0
1995	32.7
1996	34.7
1997	34.5
1998	34.0
1999	32.7
2000	35.1
2001	33.8
2002	34.5
2003	35.2
2004	35.4
2005	34.7
2006	35.7
2007	35.8
2008	34.9
2009	36.2
2010	35.6
2011	35.6
2012	37.0

Warming Trend of Nighttime Temperatures in Plumas County beginning about 1990 likely being caused by an increase in greenhouse gases *'trapping' daytime heating energy.*

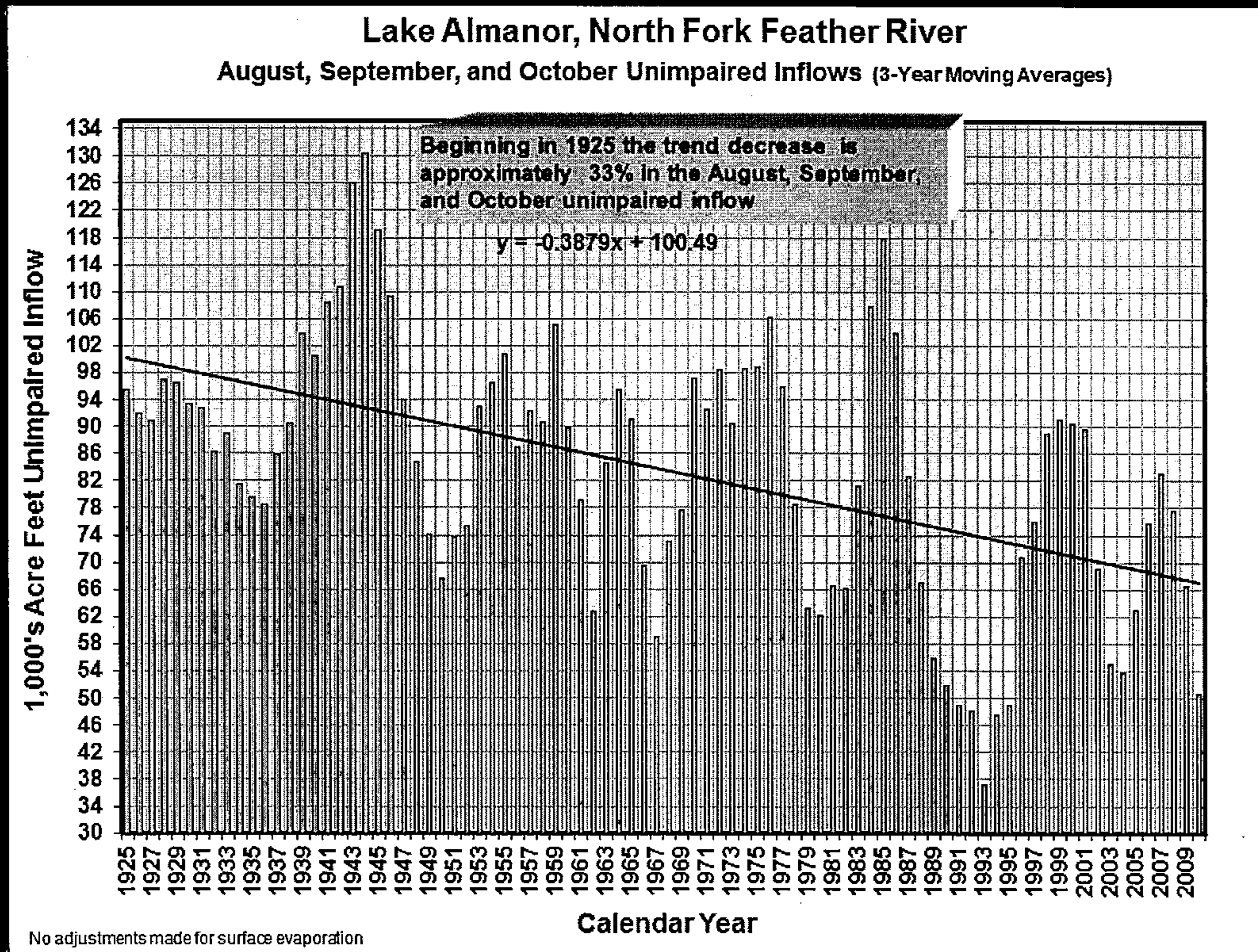
12-Month Period Ending in August
AVERAGE 32.303
MEDIAN 32.138
MINIMUM 28.817
MAXIMUM 37.050
SKEWNESS 0.562
COEFF OF VAR 0.049
SIGMA (RMS) 32.345
NUMBER OBS 108.000


Canyon Dam (Lake Almanor) Upper North Fork Feather River Elev. 4,560'
Average of July & August (62-days) Daily Minimum Temperatures in ⁰F
July &August Ave Monthly Minimum Temp
5-Yr Centered Moving Ave
Linear (July &August Ave Monthly Minimum Temp)
1945-2013
Average July & August(62-days) Minimum Temp
An approximate 5.5 ⁰F rise in night time temps during past 69 years

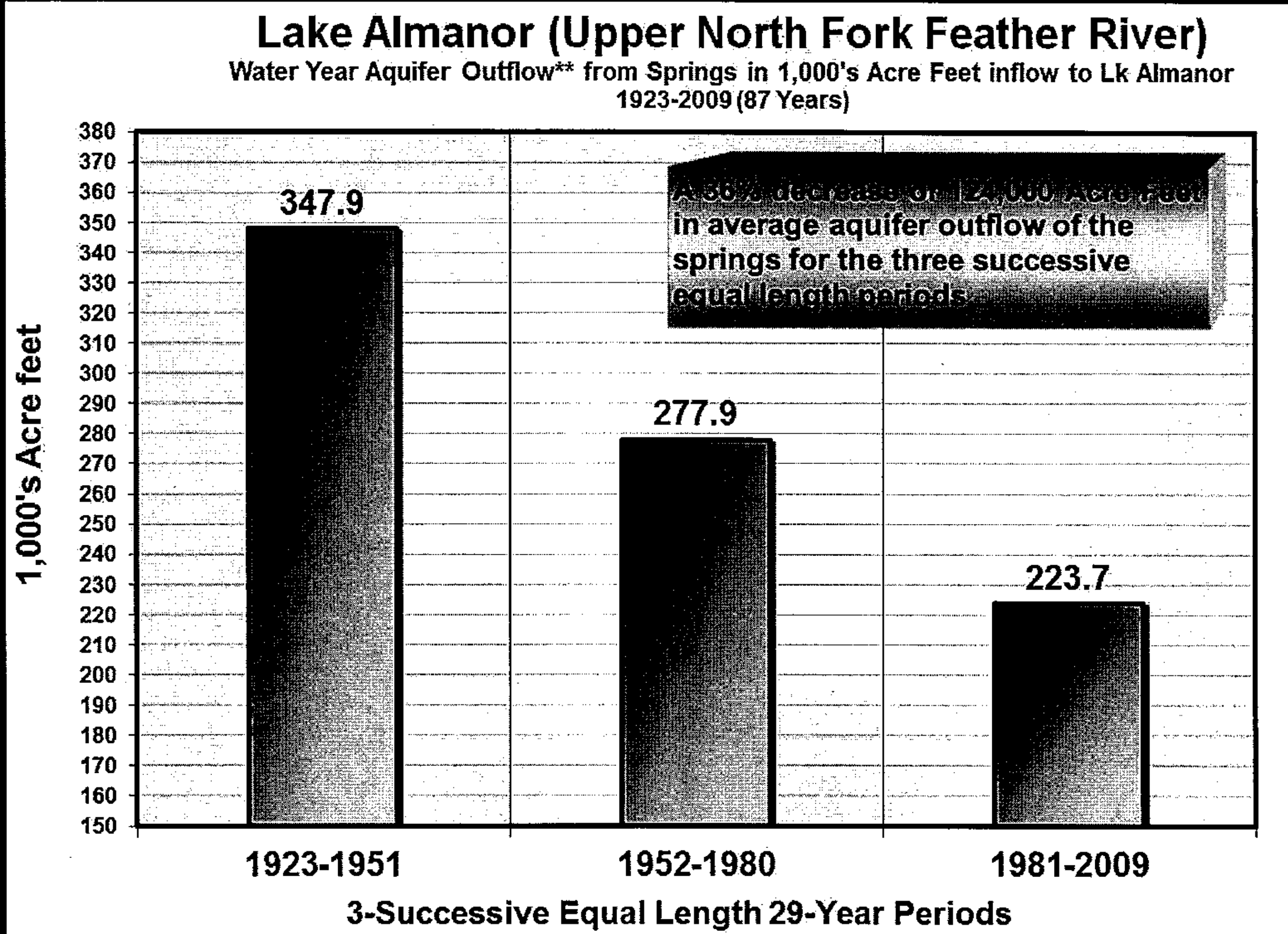
A Graphical Comparison of Canyon Dam Precipitation Compared With Runoff Utilized to Identify Increased Evapotranspiration which Started in the mid 1980's



For the Upper North Fork Feather @ Lake Almanor Late Summer and Fall Base Flows (Aquifer Outflow) Show a Declining Trend in Recent Years

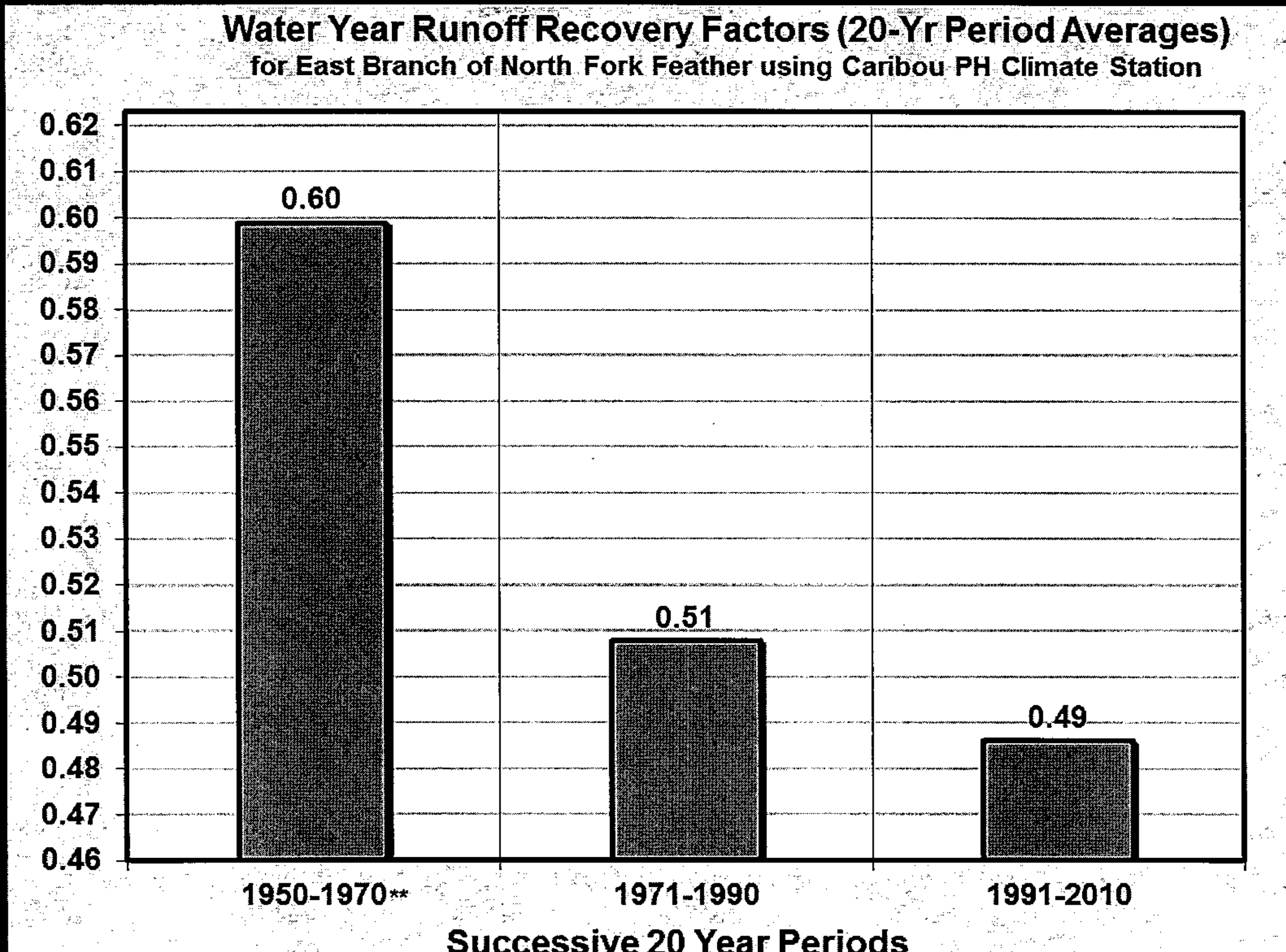


The Decline in Aquifer Outflow of the Springs Shown as Successive Equal Length 29-Year Periods



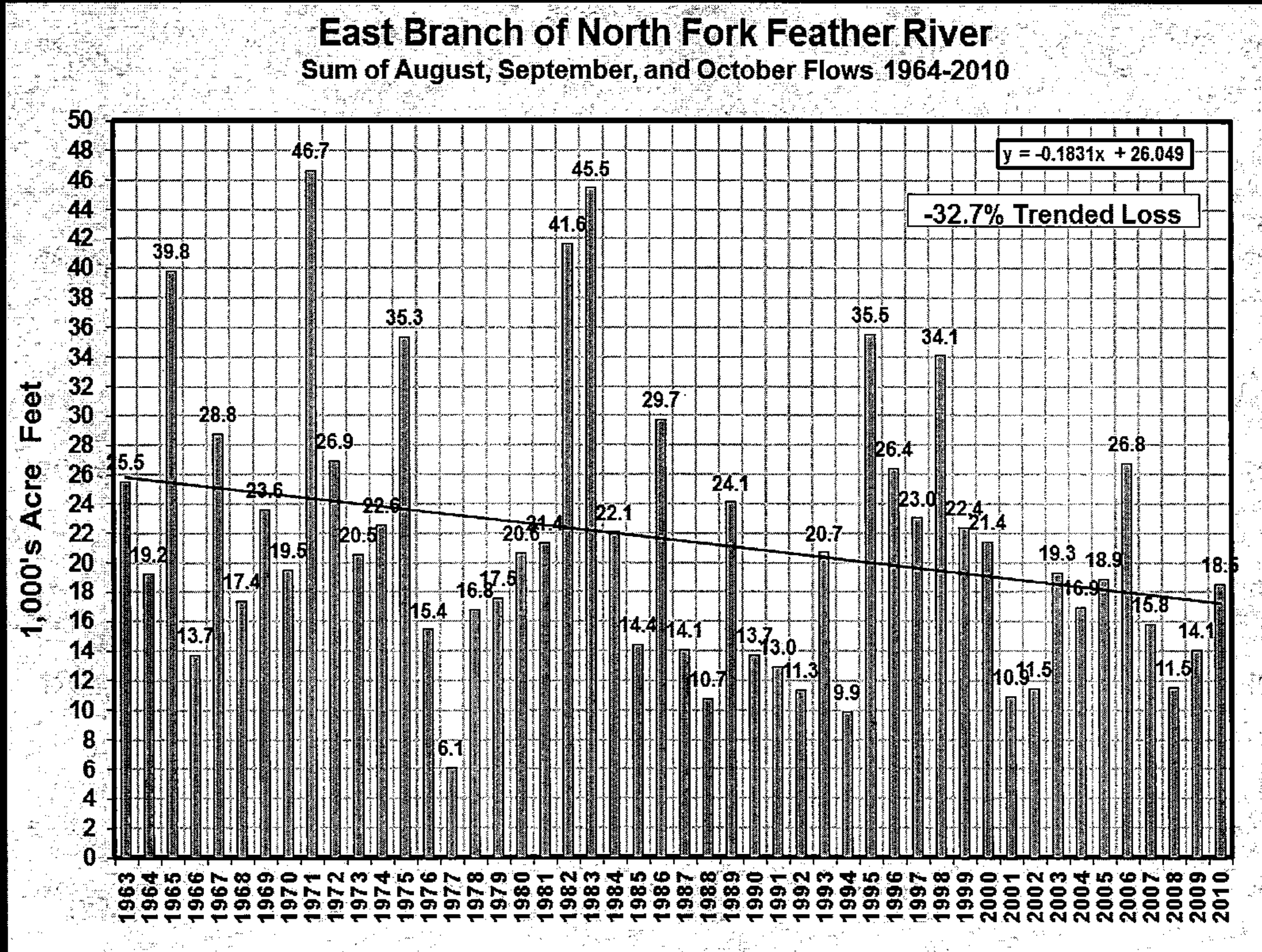
** Aquifer Outflow of Springs calculated from minimum daily flow in Aug & Sept using (1* prev yr & 2*current year)/3

Revealing A Loss of Surface Runoff Starting in the 1970's Due Mostly to Increased Evapotranspiration

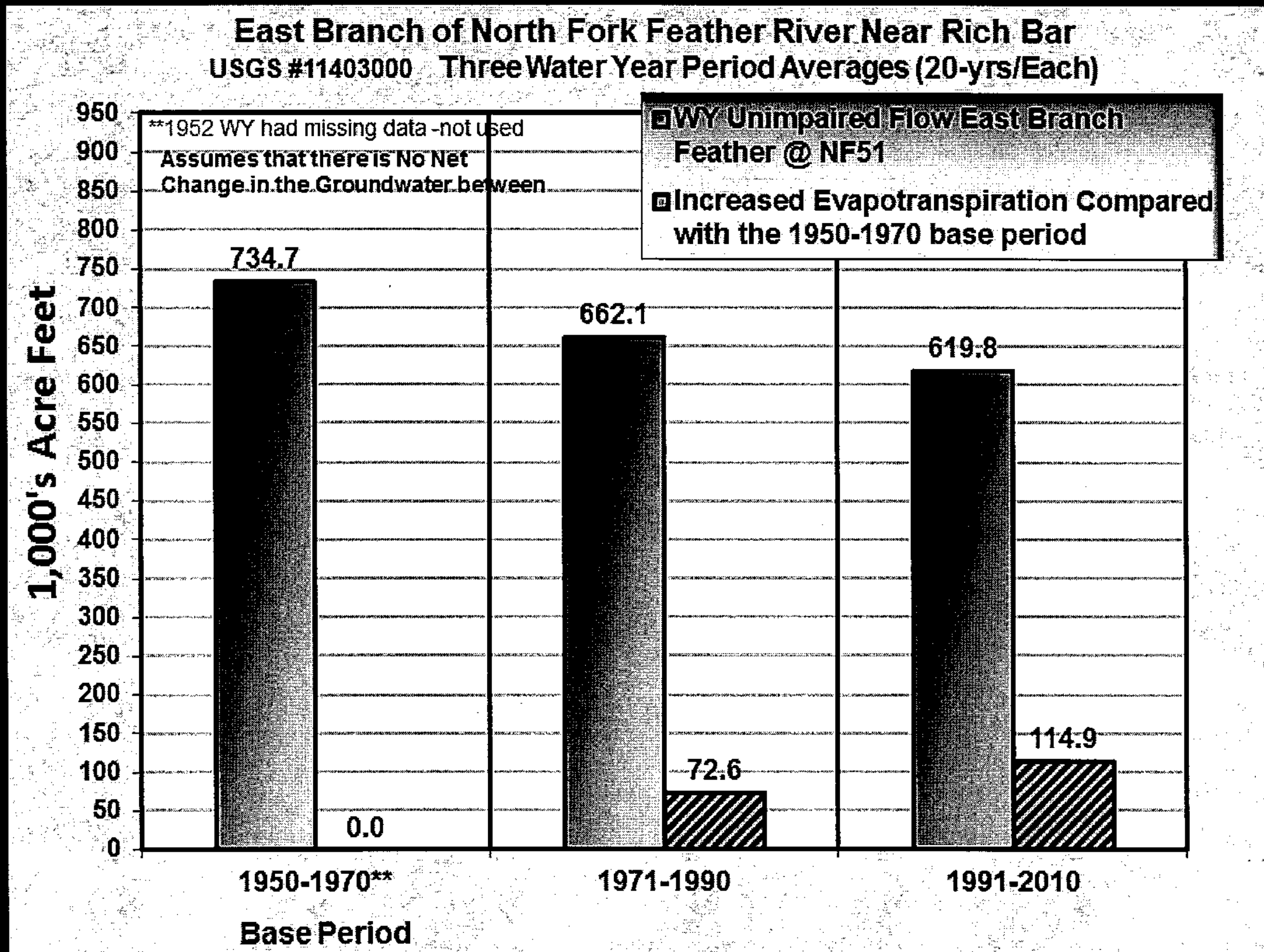


* 1952 has missing data and was not used

Decline in Late Summer and Fall Base Flows for East Branch of the North Fork Feather River



The Successive Decline in Water Year Runoff from The East Branch of the North Fk Feather River along w/Increase in Evapotranspiration



ANALYZING THE IMPACT OF CLIMATE CHANGE ON MONTHLY RIVER FLOWS IN CALIFORNIA'S SIERRA NEVADA AND SOUTHERN CASCADE MOUNTAIN RANGES

Gary J. Freeman[1]

ABSTRACT

The impact of climate change on monthly river flows in California's Sierra Nevada and southern Cascade Mountain Ranges and its potential to impact hydroelectric production was analyzed to determine changes that have taken place in two successive 35-year periods during the past 70 years. Unimpaired monthly flows from both California's Department of Water Resources' (CDWR) Data Exchange Center's (CDEC) files and from Pacific Gas and Electric Company's (PG&E) operational subbasin runoff forecasting files for the Feather River were analyzed for comparison of the two periods. A notable change was the shift of snowmelt runoff from the April through July period into the month of March. March flows were larger for the more recent 35-year period for all of the flow points analyzed in the Sierra and southern Cascades including two subbasins on the upper North Fork Feather River where rain shadowed climate change impact has significantly reduced both snowmelt and water year runoff in the more recent 35-year period. The increase in March runoff appears to be a combination of mostly earlier snowmelt due to warming temperatures and from an increase in proportion of March precipitation that now occurs as rainfall. In northern California both the shift of snowmelt into March and the reduction of snowpack overall has resulted in reduced late spring and summer flows during the months of April through June. Subbasins south of the Yuba River have for the most part increased overall snowmelt runoff for the March 1 through July 31 period, while subbasins from the Yuba River north have remained either equal or declined in snowmelt runoff in recent years. Both increased elevation and orographic cooling seem to be critical for delaying the impacts of climate change on affecting spring and early summer runoff. For a rain-shadowed subbasin such as Lake Almanor, the recent 35-year period shows a 22% decline in the April through July runoff caused primarily from a combination of: 1) earlier snowmelt, 2) increased proportion of precipitation occurring as rainfall in recent years with less snowfall overall, and 3) reduced aquifer outflow from springs. (KEYWORDS: climate change, subbasin, unimpaired flow, orographic, hydroelectric)

INTRODUCTION

The warming climate has changed the timing of spring runoff in the mountainous areas of California. Large watershed unimpaired flows were analyzed and compared throughout the Sierra and southern Cascades for two successive 35-year periods. Utilizing the same two periods for comparison, an analysis was also performed for several subbasins on the Feather River, a large river in northern California. In a comparison of the two periods, the more recent period shows a shift of snowmelt runoff into March. Also a greater percentage of the March precipitation now typically occurs as rainfall in recent years which results in an increase in rainfall-generated runoff during the month of March. This climate related change is supported by the findings of Knowles et al., (2006) and Mote et al., (2005). Shifting the spring freshet to earlier in the year typically results in less runoff being available for summer and fall flows. For PG&E, a large investor owned California gas and electric utility that manages its reservoirs to fill in late spring and early summer to meet its summer and fall hydroelectric needs for peaking power, the combination of a decline in the April 1 snowpack (Freeman, 2010), filling mountain reservoirs from snowmelt earlier in the year, and an increasing dependence on rainfall for filling is anticipated to eventually lead to increased likelihood for spill from PG&E's relatively small mountain reservoirs. The higher elevation subbasins in the southern Sierra are less influenced from climate change with regard to getting precipitation in the form of rainfall in March. However the March average for the 1977-2011 35-year period still shows an increase in runoff for the more recent of the two 35-year periods. This observed increase in March inflow seems to occur universally throughout the Sierra and southern Cascades. The earlier spring snowmelt runoff period may also be negatively impacting aquifer recharge on northern California's porous volcanic watersheds (Freeman, 2008, 2010, and 2011). This loss of recharge opportunity may be revealing itself in the observation that aquifer outflow of springs for the upper North Fork Feather River @ Lake Almanor has steadily declined during the past three decades. A similar effect has been shown for the McKenzie River in Oregon by Jefferson et al., (2008).

Paper presented Western Snow Conference 2012

[1]Power Generation Department, Pacific Gas &Electric Co., Mail Code N13A, P.O. Box 770000, San Francisco, CA 94177, GJF2@pge.com

Snowmelt results in a slow somewhat steady infiltration downward into the soils, which eventually reaches the water table and helps recharge groundwater. Increased runoff into mountain reservoirs during the January through March period has some potential to reduce the historical snowmelt pulse that typically occurred in April through July on many watersheds. For hydroelectric operators such as PG&E, getting some runoff into reservoirs prior to April 1 provides reservoir operators with an opportunity to run the water through powerhouses rather than wait for the historical April through July runoff from snowmelt. Historically prior to 1977, a larger proportion of the January through March precipitation came as snowfall. Beginning in mid-to-late April in years prior to 1977, the runoff from snowmelt during years of average or greater wetness would take place beginning in early April , quickly filling the relatively small mountain reservoirs, with excess snowmelt runoff often spilling at diversion dams and bypassing powerhouses. The pricing for hydroelectric energy produced in February and March is often fairly good and is always valued higher than zero dollars, which is the consequent value of water spilling past powerhouse diversion dams. However the down side of a declining snowpack is that there is increasing risk from supply uncertainty when relying on an increasing proportion of precipitation occurring as rainfall. Snowpack is frozen water in storage and can be accounted for with reasonably high certainty; however the uncertainty of remaining weather and increasing dependence on future precipitation for filling reservoirs greatly increases operational risk for both spill and for not filling. Faced with the uncertainty of whether or not there will be sufficient precipitation in the spring for filling reservoirs, reservoir operators often find themselves holding onto or storing additional water in attempt to increase assurance for filling the seasonal reservoirs. If in late March, the reservoir operator has mostly full reservoirs, and March turns out to be wetter than normal with most precipitation occurring in the form of rainfall, the reservoirs can quickly fill and spill past the powerhouse's diversion dam with consequent hydroelectric generation loss. The water release planning period is decreased from the historically longer, mostly gradual snowmelt duration of 2-3 months, to a few days. Receiving short notice of a warm storm's arrival in the form of a weather forecast and the consequent filling of a small reservoir of 62 hm^3-148 hm^3 in size (50 TAF-120 TAF) is typically not more than a few days to a week. There is often inadequate time to increase powerhouse flows and utilize the water efficiently for hydroelectric production, especially for large rain producing storms. For PG&E during storm periods, the flumes and canals are typically operated with increased freeboard during storm periods to reduce the likelihood for storm related damage to the facilities such as sometimes occurs from falling trees and debris slides. If a water carrying conduit becomes damaged from storm related incidents, the consequent snowpack and winter mountain conditions may increase the time that it will take to complete a repair. In the meantime the canal downstream of a break or damaged area may not be able to carry water. In the high country, lack of sufficient water in an open conduit may result in the canal or flume filling with snow, or in some cases, the empty structure 'floating' or being buoyed upward due to lack of having sufficient weight for the water being displaced by the structure's base within the soil.

COMPARING TWO EQUAL LENGTH PERIODS OF RUNOFF DATA

In order to detect possible effects of climate change, two successive 35-year periods were selected and their means and standard deviations compared for differences. PG&E maintains unimpaired natural runoff for over 100 locations in the Sierra, southern Cascade, and the Coastal Mountain Ranges of California. Nearly all of these points are computed daily and kept current for the purpose of forecasting runoff and performing water studies in connection with the operation of PG&E's hydroelectric system. The two periods selected for comparison were 1942 through 1976 (35-years) and 1977 through 2011 (35-years). The 1976 and 1977 water years were selected as the dividing point for the two 35-year periods because both years were very dry with 1977 being a second consecutive year of drought and drier than 1976 in terms of both precipitation and surface runoff. Much of the change that has occurred in recent years appears to have begun in the mid-1970's. CDWR likewise computes unimpaired monthly natural flows for most of the major rivers that drain the Sierra and southern Cascades, but typically do so for the entire river to a point at or close to a large multipurpose reservoir near the floor of the Central Valley. These large multipurpose reservoirs are typically referred to as the 'rim' reservoirs as they are situated along the rim of California's Central Valley. While the study was mostly performed at the subbasin level of detail within the upper reaches of the large rivers, for the sake of simplicity many of the table and chart comparisons in this paper compare the monthly runoff for 13 of the large rivers which range from the Klamath River near the Oregon Border to the Kern River near Bakersfield. In many ways this relatively low resolution analysis summarizes the overall findings that were observed at the operational subbasin level of detail. Compared with the other large rivers, a primary difference was observed for the Feather River where rain shadowed operational subbasins lack the orographic cooling condition and the runoff is much more impacted from climate change than for the Feather River as a whole. For the Feather River Basin, some of the subbasins are analyzed for their somewhat unique climate change response. For these few rain shadowed cases, the winter minimum air temperatures have warmed significantly above the surrounding, more orographically influenced subbasins. The rain shadowed subbasins indicate a relatively large water year loss for the more recent of the two 35-year periods. In both cases this surface runoff loss appears to have resulted mostly from increased evapotranspiration.

THE WATER YEAR

Figure 1 indicates an overall linear trend in water year change in runoff for the more recent 35-year period compared with the earlier period that ranges from -10.6 percent for the Klamath River at Orleans near the Oregon border to +17.2% for the Kern River near Bakersfield. This increasing trend needed to be removed to evaluate the monthly flows. For the two time periods analyzed, the rivers show a gain in water year runoff for the more recent period from the American River southward. This increase may in part be related to increased elevation and relatively strong orographic cooling associated with the central and southern Sierra. While there is some tendency

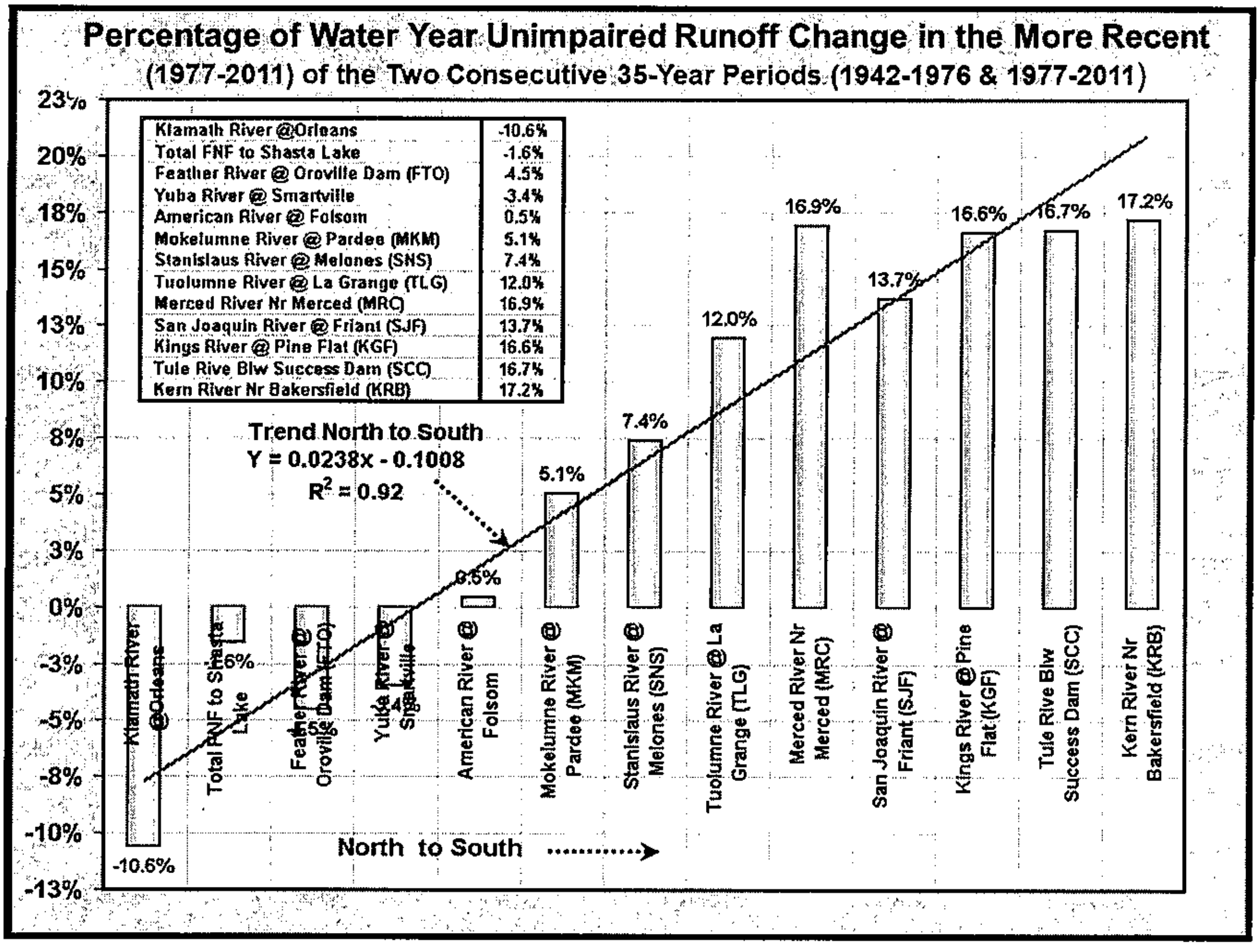


Figure 1. Water year runoff quantities for the American River southward generally increase in the more recent 1977-2011 period compared with the earlier 1942-1976 period.

for precipitation to increase in the north to south direction, the percent increase has a lot of variance. The northern Sierra is much lower in elevation overall, has several rain shadowed subbasins, and as such does not overall have the extent of orographic cooling effect. Orographic cooling is more common for subbasins along the west facing side of the Sierra Nevada, which encounter the eastward frontal flow from storms onto the relatively steep inclined windward slopes. For PG&E with its hydroelectric system distributed over the Sierra Nevada and southern Cascades, the overall impact from climate change has been somewhat of a "no net impact" at least during the past couple decades and this situation will likely continue to be the case for at least the near future. The increased runoff for the southern Sierra watersheds and the benefits of increased hydroelectric generation that results from an earlier snowmelt with increased rainfall overall leads to an earlier filling of the relatively small mountain reservoirs. Rather than waiting for snowmelt, which has historically started in April with high likelihood for spill in years with above average late spring snowmelt runoff, beginning in mid- January stored water is now increasingly released from the reservoirs with decreased risk for spill past the powerhouses. The downside risk for the operator is that with this earlier rainfall-caused inflow, reservoir planners are now becoming increasingly dependent on the uncertainty of remaining weather, often in the form of rainfall for filling reservoirs.

SUB-PERIODS WITHIN THE WATER YEAR

In order to remove the trending change in water year runoff for the 13 rivers analyzed in this study, the average monthly runoff for each of the subbasins and watersheds for the two comparative periods were divided by that period's water year total runoff. Converting the two successive 35-year periods into a monthly percentage of the water year totals produced a relatively trend-free set of monthly ratios to use in comparing the two periods irrespective of differing average water year totals. The watersheds were then compared from north to south along the Sierra and southern Cascades. The PG&E hydroelectric system is primarily divided into operational subbasins based on a combination of both diversion dams and the larger seasonal storage reservoirs. Runoff is forecasted and accounted for at each diversion dam. Some rivers such as the Feather River above Lake Oroville is forecasted with water release planning taking place at PG&E for approximately 20 operational subbasin diversion points. Each of these diversion points have sidewater unimpaired inflows associated with them, which allows for a fairly detailed elevation-based climate analysis that utilizes

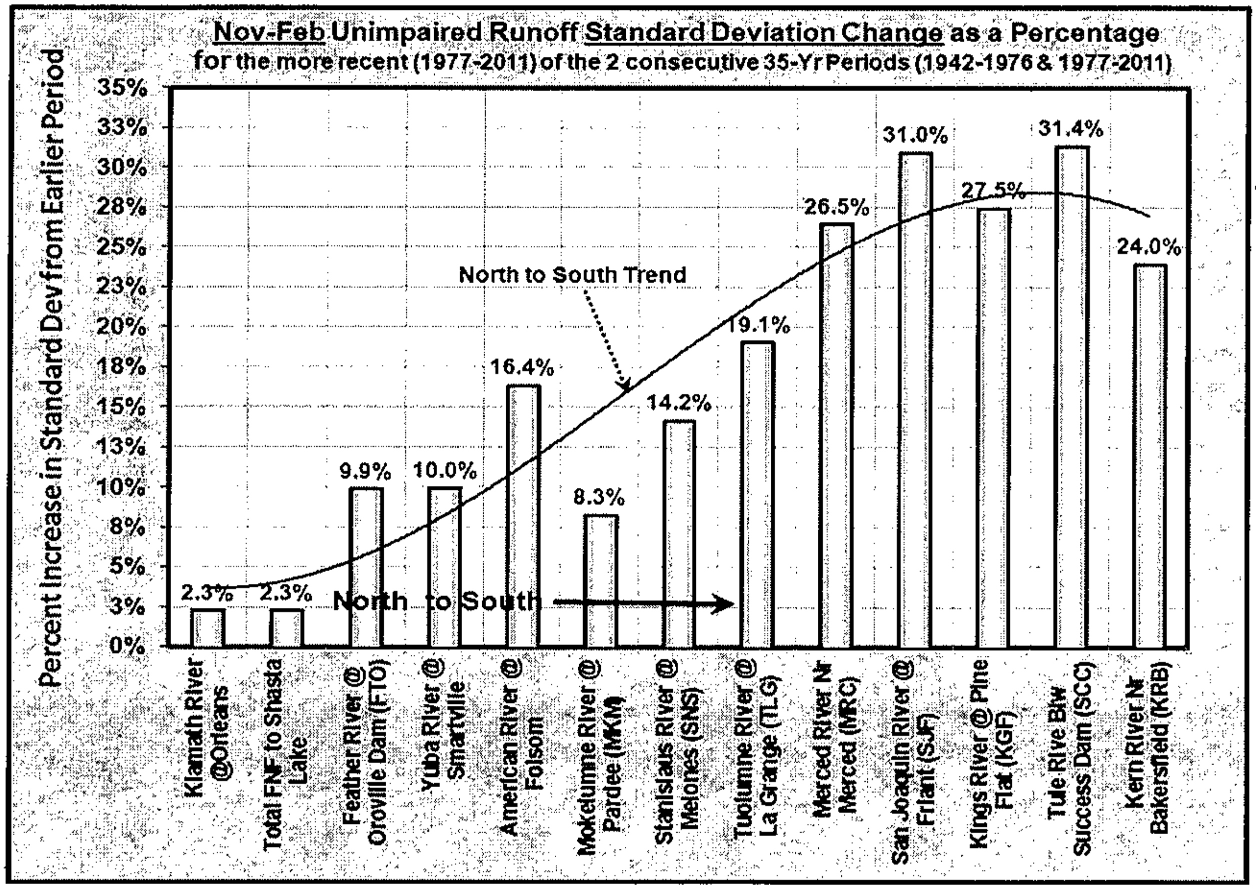


Figure 2. The percentage increase in standard deviation for the November through February runoff in the more recent (1977-2011) of the two 35-year periods.

calculated and daily compiled subbasin and river reach runoffs. An analysis of the Feather River subbasins was done to identify the runoff impact of climate change on orographic and rain shadowed subbasins.

Standard Deviation increase in the More Recent Period

The standard deviation for both the water year and the November through February 4-month sub-period increased in the more recent of the two 35-year periods. For the November through February 4-month sub-period, the trend in general increased from north to south, with somewhat of a leveling off for the Merced River southward. For the water year period, the standard deviation tended to decrease on both sides of the Merced River. It's fairly characteristic for the rivers that flow over the exposed granites, that they have historically had a large variance in flows in which either being very dry or very wet is almost the norm. What is observed is that with climate change the variance and related standard deviation increases in the more recent period with standard deviation increasing as much as much as 31 percent for the November through February period and up to 47 percent for the 12-month October 1 through September 30 water year period. Figure 2 and Figure 3 show the standard deviations for both the November through February and the water year periods for the thirteen major rivers.

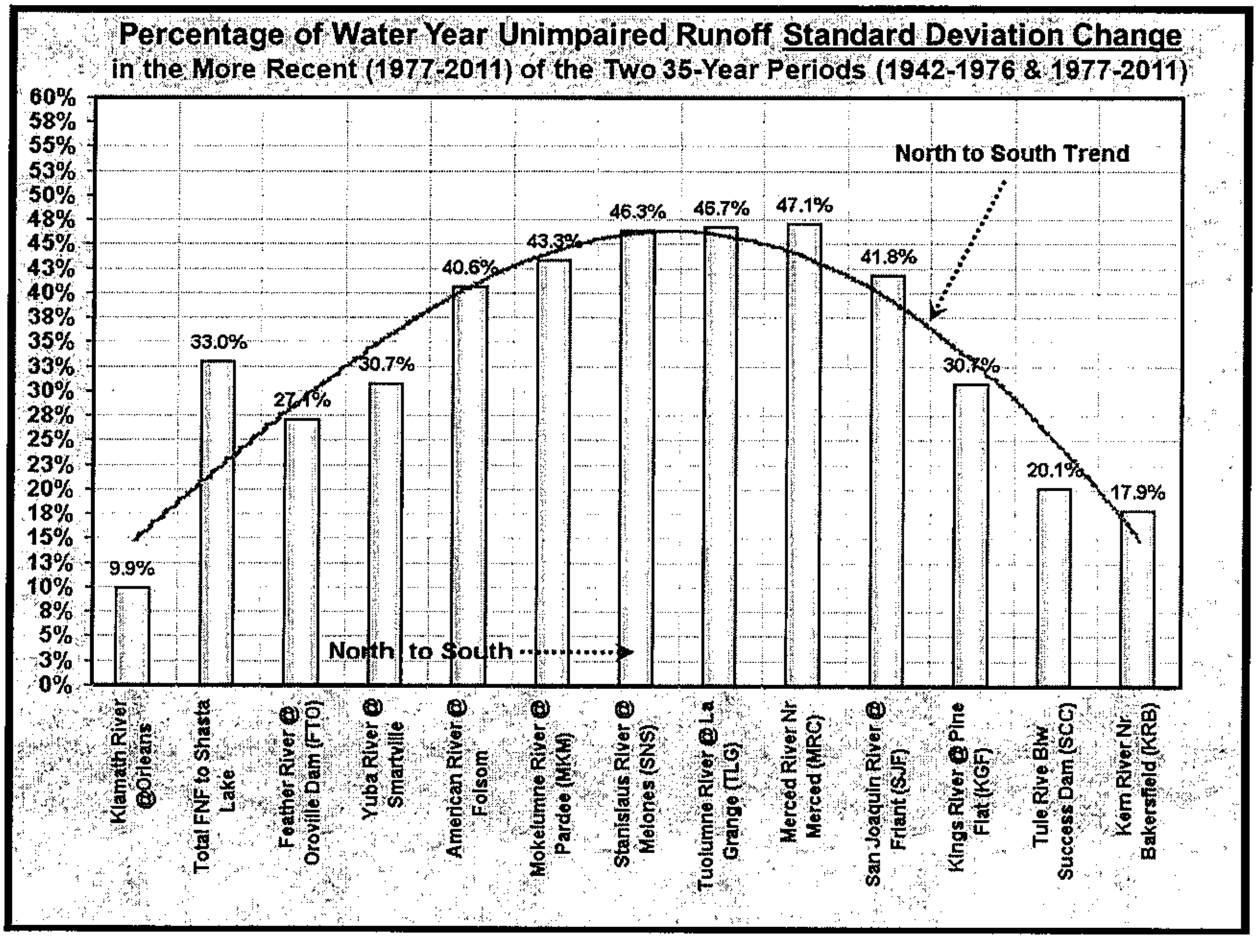


Figure 3. The percentage increase in standard deviation for the water year runoff in the more recent (1977-2011) of the two 35-year periods. The Merced River has the greatest increase in standard deviation.

<u>Shift of the April through July into Earlier Months</u>

Figure 4 illustrates the impact that climate change has on each of several large river basins that range in location from north to south from Northern California's Klamath River south to the Kern River near Bakersfield. A large portion of the April through July runoff has shifted into March and a lesser amount into February. The largest shift into March from the April through July period is 4.4% for the Feather River at Oroville Dam. Both north and south of the Feather River, the trend shifts downward. The Kern River, which is at the far right of the Figure 4 chart shows a slight increase of runoff shift into March. Due to the Kern River's upper basin, which drains distinctly southward behind the initial Sierra Crest, the Kern River as shown in Figure 5 does not have the same basin orographic orientation as the drainages to the north, but instead has a somewhat rain-shadowed configuration. In spite of the position of its downstream reach which empties into the San Joaquin Valley near Bakersfield; its headwater drainage has a somewhat blocked configuration giving it a more northern characteristic equivalent to that of the San Joaquin River in terms of the March ratio.

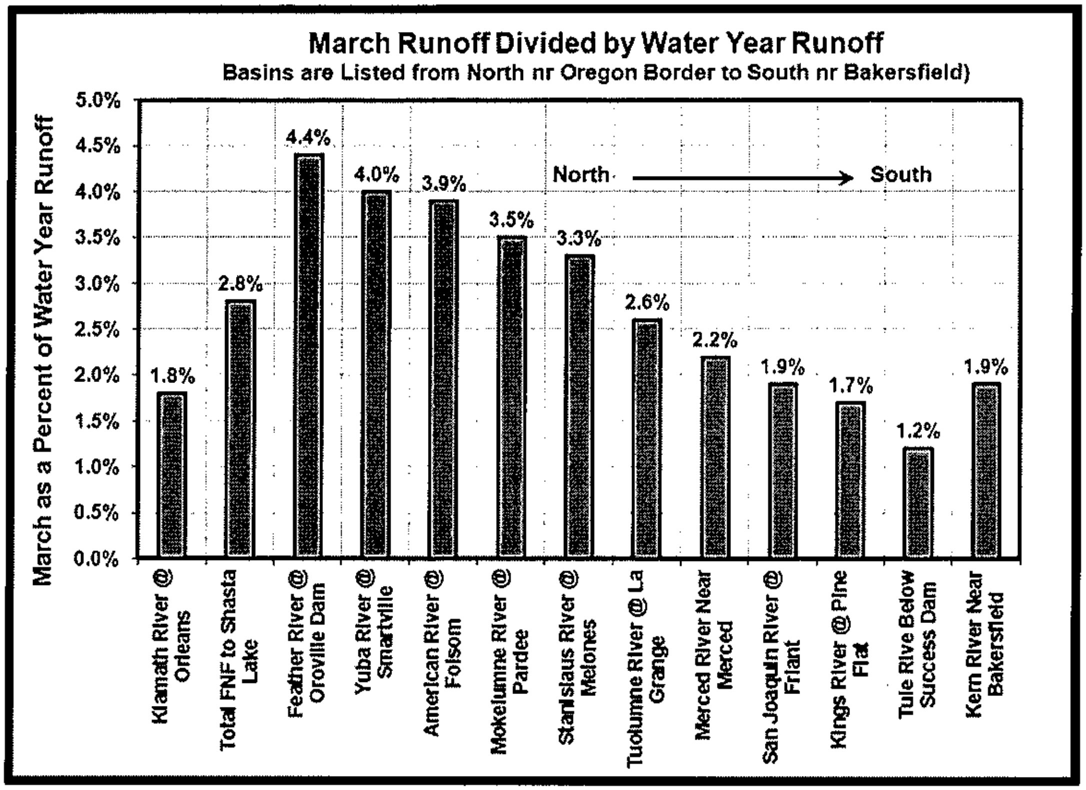


Figure 4. March runoff divided by water year runoff. Left to right order corresponds to north to south orientation.

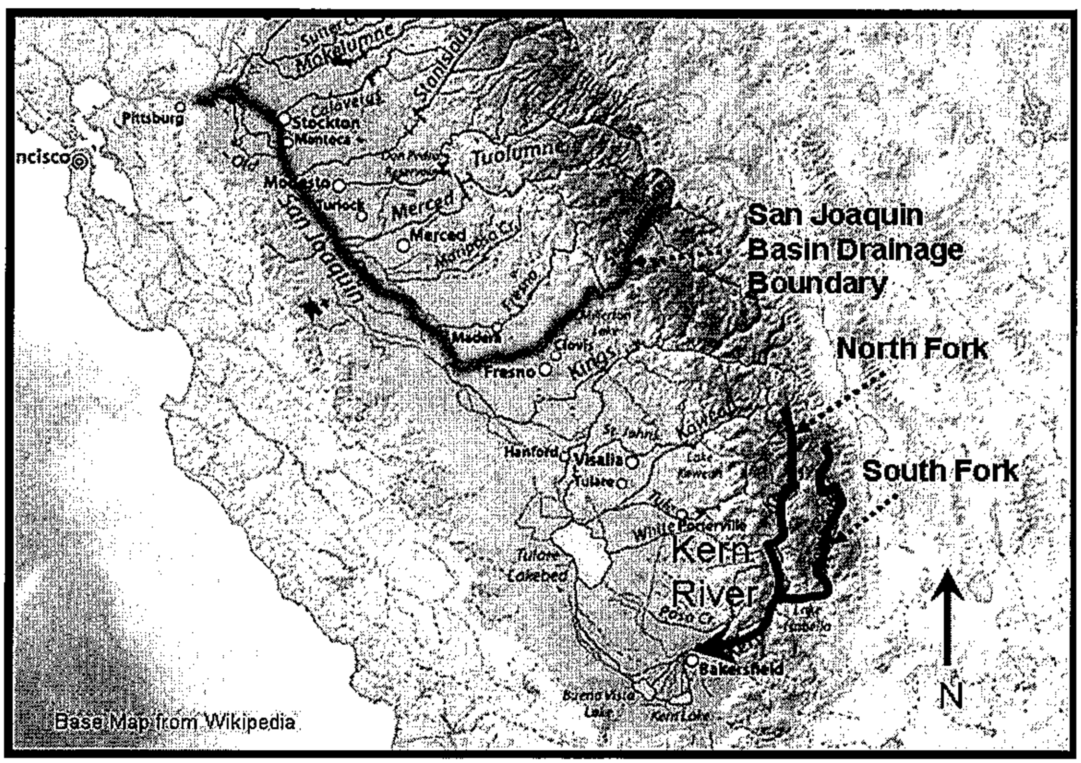


Figure 5. The Kern Headwaters differs from most Sierra Rivers by turning northward along the Sierra's southern block's Kern Canyon Fault behind the blocking influence of the Sierra Nevada's Great Western Divide sub range.

In terms of analyzing the effects of climate change on runoff, orographic effect seems to have major implications on how runoff in the Sierra and southern Cascades is impacted. Both the Klamath River and the combined Sacramento, McCloud, and Pit Rivers @ Shasta appear to likely have greater orographic cooling overall compared with the Feather River. Elevation overall appears to provide a benefit against the effects of climate change providing that the elevation has the windward benefits from steep upward cooling. In the case of the Kern River those windward benefits appear to have been slightly dampened by the Kern Basin's shape as it cuts behind and becomes somewhat blocked by a portion of the Sierra crest. The Kern River is the only major Sierra River to flow north to south. It runs nearly a straight line down the 87-mile long Kern Canyon Fault from the highest Sierra peaks including Mt. Whitney and south in two main forks that have carved dramatic canyons along their paths bordered to the west by the Great Western Divide, one of the largest and highest mountain sub ranges in the Sierra Nevada Mountains. The Kern River, the result of the Kern Fault is located on the southern block, which 60-20 million years ago emptied into the Colorado River to the East, but during the past 20 million years has shifted its outlet westward into the San Joaquin Basin, and within the past 12 million years shifted its outlet toward the city of Bakersfield (Hill, 2006; Nadin, 2007). Because of it not being a part the main Sierra block that tilted toward the west, the effect of orographic cooling from winter storm activity is likely slightly less than for much the more exposed west-facing, windward slopes of the Kings and Tule Rivers just north of Bakersfield. Freeman (2011) discusses the importance that subbasin and basin orientation has in minimizing and buffering the impacts from climate change.

MONTHLY CHANGES

Table 1 lists as a percent the monthly runoff divided by the water year runoff ratios for the more recent 35-year period for the 13 rivers studied. Table 2 lists the actual average monthly flows for October through September for the same 13 rivers. Unimpaired runoff data utilized for both Tables 1 and 2 was taken from the California Department of Water Resource's Data Exchange Center (CDEC). Creating monthly ratios such as was done for Table 1 helped remove the effect of some watersheds having had an increasing 35-year water year average and others a decreasing water year average for the more recent period. In addition to March having increased runoff in every basin and subbasin analyzed, February likewise gained runoff for several subbasins. A few cases showed a small January increase. Somewhat surprisingly October through December showed a general decrease in runoff percent of the water year for the more recent period. It was almost as if the months of February and March increased at the cost of the October through December period' increase and in some cases the fall runoff as well. Figure 6 shows the two 35-year periods with a monthly comparison of the month/water year flow ratios as percentages of the water year for the North Fork of the Feather River at Poe Diversion Dam. When the actual monthly flows were reviewed, the second 35-year period has a much changed water balance with significantly more water entering into evapotranspiration rather than surface runoff. The mean surface runoff for the 1977-2011 water

Table 1. Monthly water year ratios* for the two successive 35-year periods: 1942-1976 and 1977-2011. Thirteen large rivers are listed.

*Monthly Percentages = Monthly Runoff/Water Year Runoff					General Increase		General Decrease					
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Klamath River @Orleans	-0.3%	-0.7%	-0.2%	-1.4%	0.9%	1.8%	0.0%	0.3%	0.1%	0.3%	0.1%	-0.1%
Total FNF to Shasta Lake	-0.5%	-1.0%	-1.1%	-0.4%	1.0%	2.8%	1.2%	0.4%	0.2%	0.0%	-0.1%	0.0%
Feather River @ Oroville Dam (FTO)	-0.5%	-0.2%	-0.8%	-0.4%	1.5%	4.4%	1.4%	1.5%	0.6%	-0.2%	-0.2%	0.1%
Yuba River @ Smartville	-0.5%	-0.7%	-1.1%	-0.6%	1.6%	4.0%	0.4%	1.2%	0.9%	0.2%	-0.2%	-0.1%
American River @ Folsom	-0.2%	-0.7%	-1.2%	-0.4%	2.3%	3.9%	0.6%	1.9%	1.1%	0.0%	-0.1%	0.0%
Mokelumne River @ Pardee (MKM)	0.1%	-0.9%	-1.8%	0.7%	1.5%	3.5%	0.9%	2.6%	1.4%	1.1%	0.1%	0.2%
Stanislaus River @ Melones (SNS)	0.3%	-0.5%	-1.5%	1.4%	2.5%	3.3%	0.7%	3.5%	1.7%	0.2%	0.0%	0.2%
Tuolumne River @ La Grange (TLG)	0.3%	-0.8%	-1.7%	0.9%	1.1%	2.6%	0.5%	2.3%	1.6%	1.0%	0.6%	0.4%
Merced River Nr Merced (MRC)	0.3%	-0.9%	-2.0%	1.4%	1.5%	2.2%	0.5%	3.1%	1.3%	1.5%	0.6%	0.4%
San Joaquin River @ Friant (SJF)	0.2%	-0.4%	-1.2%	0.8%	0.7%	1.9%	0.2%	2.2%	1.1%	1.0%	0.3%	0.3%
Kings River @ Pine Flat (KGF)	0.3%	-0.2%	-1.1%	0.6%	0.7%	1.7%	0.0%	2.6%	1.2%	0.9%	0.3%	0.5%
Tule Rive Blw Success Dam (SCC)	0.3%	-0.4%	-2.6%	0.2%	2.1%	1.2%	1.3%	2.2%	0.9%	1.0%	0.5%	0.3%
Kern River Nr Bakersfield (KRB)	-0.1%	-0.3%	-1.5%	-0.1%	0.8%	1.9%	0.1%	0.9%	0.5%	0.3%	0.1%	0.1%

Table 2. Actual runoff listed for each of the 13 river basins. In general basins and their subbasin components for the American River southward showed an increase in their water year averages for the more recent 35-year period.

RIVER		All Water Values are in Cubic Hectometers (1 hm3 = 810.71 Acre Feet)												
Klamath River @Orleans (KLO)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY
	1942-1976 (35-Yrs)	118.7	342.9	746.6	1,034.9	859.3	843.6	810.4	781.7	450.4	159.8	88.5	71.3	6,308.0
	1977-2011 (35 Yrs)	91.4	264.6	658.7	845.9	818.9	853.4	722.9	682.4	399.1	160.1	82.7	60.0	5,640.1
														-10.6%
Total FNF to Shasta Lake (SHA)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	337.7	464.7	769.5	1,004.3	1,004.4	992.7	915.1	674.5	429.3	309.4	277.9	270.3	7,449.8
	1977-2011 (35 Yrs)	293.3	383.1	673.5	960.5	1,060.2	1,181.4	812.5	692.8	438.8	306.3	266.9	264.3	7,333.4
														-1.6%
Feather River @ Oroville Dam (FTO)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	156.3	256.7	533.7	706.0	670.5	740.4	906.8	866.1	453.9	208.8	136.8	111.9	5,747.8
	1977-2011 (35 Yrs)	120.8	233.4	467.4	649.6	722.1	945.6	789.6	743.4	397.7	187.0	120.6	110.5	5,487.8
														-4.5%
Yuba River @ Smartville (YRS)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	51.1	128.9	294.1	377.3	344.0	362.7	455.6	538.5	283.1	74.1	34.3	26.1	2,969.7
	1977-2011 (35 Yrs)	35.7	104.6	251.7	347.7	378.1	465.6	427.5	484.4	247.4	76.2	26.3	22.4	2,867.7
														-3.4%
American River @ Folsom (FOL)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	38.2	126.8	300.0	417.4	361.2	423.9	551.1	655.4	358.2	90.9	24.4	14.7	3,362.4
	1977-2011 (35 Yrs)	30.9	104.7	262.3	404.8	439.4	557.0	535.0	592.9	323.3	91.1	20.2	16.0	3,377.8
														0.5%
Mokelumne River @ Pardee (MKM)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	7.4	29.1	58.9	68.7	67.6	87.1	152.7	245.5	154.3	31.2	6.4	3.2	912.0
	1977-2011 (35 Yrs)	8.6	22.3	44.3	78.6	85.1	124.8	157.7	232.7	148.6	43.4	7.4	4.8	958.3
														5.1%
Stanislaus River @ Melones (SNS)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	11.3	40.3	83.4	102.3	98.0	137.4	236.6	364.7	228.3	67.0	15.7	6.8	1,391.8
	1977-2011 (35 Yrs)	16.0	35.3	66.7	130.1	142.4	197.6	244.1	339.4	219.3	75.7	17.5	10.8	1,494.7
														7.4%
Tuolumne River @ La Grange (TLG)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	18.3	71.3	136.1	153.4	154.0	200.8	327.3	556.2	441.6	143.5	26.9	10.9	2,240.4
	1977-2011 (35 Yrs)	29.2	59.4	108.6	194.3	200.2	290.7	353.4	564.9	453.3	186.9	45.1	22.8	2,508.8
														12.0%
Merced River Nr Merced (MRC)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	7.8	30.1	65.8	77.6	82.1	107.2	171.7	297.9	209.8	61.1	13.0	5.2	1,129.1
	1977-2011 (35 Yrs)	12.7	23.7	50.4	109.3	116.1	164.6	194.0	306.7	228.2	90.9	22.7	10.9	1,320.1
														16.9%
San Joaquin River @ Friant (SJF)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	22.2	46.6	88.9	100.3	110.6	152.8	279.9	533.7	459.8	197.7	61.5	27.3	2,081.4
	1977-2011 (35 Yrs)	31.2	43.6	71.5	133.4	143.1	217.7	313.8	555.4	496.6	247.4	75.9	37.1	2,366.6
														13.7%
Kings River @ Pine Flat (KGF)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	21.1	39.6	75.4	83.1	86.1	121.2	248.6	529.7	455.4	186.5	55.7	23.7	1,926.2
	1977-2011 (35 Yrs)	31.5	40.8	62.9	111.4	116.8	180.0	289.0	568.5	505.1	238.5	72.0	39.9	2,246.3
														16.6%
Tule Rive Blw Success Dam (SCC)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	1.5	5.9	14.8	19.4	19.1	28.1	28.9	27.1	12.6	3.8	1.4	0.9	163.5
	1977-2011 (35 Yrs)	2.3	6.0	12.3	23.0	26.3	36.0	31.3	27.5	16.5	6.4	2.6	1.7	190.9
														16.7%
Kern River Nr Bakersfield (KRB)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1942-1976 (35-Yrs)	20.4	26.1	44.1	46.9	47.0	67.0	111.1	183.6	158.6	81.1	36.6	21.2	843.7
	1977-2011 (35 Yrs)	22.9	27.7	36.9	54.2	63.4	97.5	131.2	206.2	180.5	98.4	43.9	26.0	988.7
														17.2%

year period is 215.6 hm^3 (174.8 TAF) or approximately 7.5 percent less than the earlier period. The April through December months all declined while the February and March runoff increased. For the American River south as seen in Figure 1, water year flows increase in the more recent period and decrease for watersheds north of the American River. Freeman (2011) hypothesizes that this increase for the major River Basins that include the American River southward may be attributable to an increase of available moisture in frontal systems for the most recent 35-year period. The orientation and elevation of the Sierra south of the Yuba River may provide sufficient orographic cooling to capture the additional moisture as precipitation, which in turn appears to be resulting in increased surface runoff for the Sierra's central and southern Sierra watersheds south of the Yuba River, which is the case at least for the two periods analyzed.

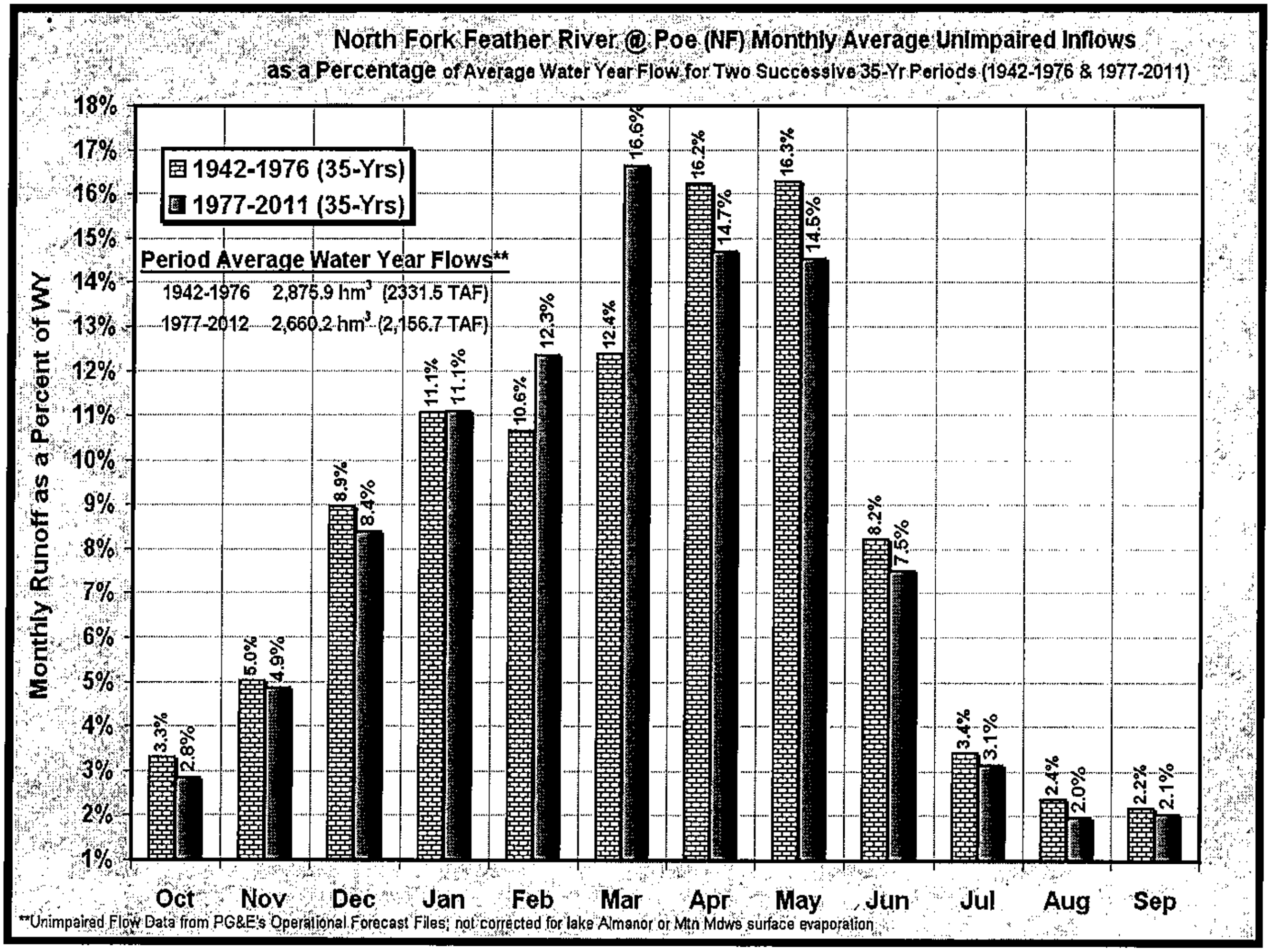


Figure 6. A comparison of the monthly/water year runoff ratios for the two consecutive 35-year periods for the North Fork of the Feather River @ Poe Diversion Dam.

In order to accurately forecast runoff for hydroelectric scheduling, PG&E utilizes a two pass regression approach in a system named PRM (Precip Recovery Method) developed at PG&E. The first pass contains a relatively long historical period of approximately 25-35 years to determine whether or not the forecast is for an average, wet, or dry period. Once the program has chosen the basic wetness type, the forecasting tool then performs a second pass regression on a much more limited set of years to improve its fit with the independent variables such as snow water equivalent, precipitation, and aquifer outflow of springs. In the face of changing seasonal runoff with climate change, PG&E's runoff forecasts handle the growing issue of runoff time series loss of stationarity, by utilizing relatively recent water years only with attention to the runoff changes such as shown in Table 2 for the larger river. Runoff for the April through July period has decreased for those watersheds north of the American River, and that decrease in spring runoff is anticipated to continue well into the mid-21st century as the climate continues to warm. Hydrologists can forecast the spring runoff with that fact in mind, which helps bias operating decisions toward less spring runoff than is being indicated by the long term historical data set. Likewise for the southern Sierra watersheds, a slight bias is given to expecting an increase in April through July and water year runoff. In all cases larger March runoff is anticipated than has historically occurred prior to 1977. In order to effectively deal with the changes being observed, PG&E is currently calibrating subbasins on the Feather River with the PRMS model (USGS Precipitation Runoff Modeling System), working in partnership with both the California Department of Water Resources and the US Geological Survey. PRMS, a distributed conceptual modeling tool that utilizes hydrological response units as described by Koczot et al., (2005) will help assist PG&E's forecasting hydrologists with an alternative physically based model that can more effectively handle temperature, evapotranspiration, soil moisture, and groundwater than the seasonal regression model by itself.

POTENTIAL IMPACT ON PG&E'S HYDROELECTRIC PRODUCTION

If the current trends in monthly and water year runoff continue, hydroelectric generation for PG&E's conventional hydroelectric system is anticipated to show little if any decline overall up through about 2025. Beyond 2025 the system overall may then likely begin a gradual net decline in hydropower production as the benefits of an earlier runoff into the mountain reservoirs likely begins to be outweighed by a number of other risk factors. Historically, the typical spring runoff quantity from snowmelt resulted in frequent spring spills as the runoff quantity exceeded both the available usable capacity of the seasonal reservoirs and the capacity of releasing snowmelt inflow through powerhouses. May and June spill at many of the mountain reservoirs occurred with a frequency of 1 in 2 to 1 in 3 years for many of PG&E's 98 reservoirs. Some of the smaller seasonal reservoirs spill every year even during very dry years. As the April through July snowmelt increasingly shifts into March and February as a result of both an increased frequency of earlier snowmelt and the change in physical form from snowfall to rainfall, the opportunity to move the inflow earlier has increased hydroelectric generation for some rivers especially for the Yuba River southward. The value for energy in February and March is typically less than for summer and fall, however it is still better than waiting for the snowmelt to start April 1 or later and then end up spilling much of the inflow from snowmelt in late May and early June after both the reservoir and powerhouse capacities have been exceeded. The energy value for water bypassing the powerhouses is often zero depending whether or not there are some downstream powerhouses that have sufficient capacity to utilize the water which is spilled past upstream lower capacity powerhouses. The overall benefit from earlier runoff in a large diverse system such as PG&E's is currently being balanced by hydroelectric losses such as are taking place on the Feather River that when balanced together appear to have at this time little or no net gains or losses in conventional hydroelectric generation. This net zero overall impact for the PG&E hydro system may possibly continue for another 12-15 years.

Balancing Energy Gains with Energy Losses Including Increased Risk for Spill

Figure 7 conceptually illustrates the impact that climate change is currently having on PG&E's hydroelectric production including increased risk for maintaining current levels of hydroelectric production being anticipated beyond 2025. Because PG&E's hydroelectric system has both Company and Partnership Projects that extend from the McCloud and Pit Rivers in northern California to the high elevation Kern River in the southern Sierra on approximately 16 major rivers in the Sierra, southern Cascade, and Coastal Mountain ranges, the operational subbasin response to current and anticipated climate change is highly diverse. In addition to subbasin diversity, historically approximately 38% of PG&E conventional hydroelectric generation comes from large springs in northern California (Freeman, 2007). This source of water is multidecadal in terms of quantitative water year supply and not necessarily dependent on a given year's precipitation, but instead depends on relatively long lag times that involve both long term increases and decreases in aquifer storage and the accumulated effect of the past 3-5 years of accumulated wetness including recharge opportunity. Some of the current identified losses include the impact of climate change for the upper North Fork Feather River rain shadowed subbasins where the water balance has increasingly resulted in increased evapotranspiration and declining outflows of the springs. For the North Fork Feather River, the runoff losses average about 308 hm^3 (250 TAF)/year. As the effects of warming continues and the snowpack continues to decline and that decline moves increasingly southward along the Sierra in extent, increasing planning uncertainty begins to increasingly take its toll on energy production. As the frozen snowpack continues to decline in an increasing number of years, the relatively small mountain reservoirs must be held higher and higher in the December through February period to help assure filling and to maximize their storage capacity for meeting summer recreation expectations and for meeting summer and fall hydroelectric peaking needs. The probabilistic opportunity cost for keeping reservoirs low beyond about mid-January is the rising uncertainty of depending increasingly on remaining weather for filling the reservoirs and less on the much easier forecast frozen snowpack for filling (Freeman, 2003). The inevitability of increasing spill in February and March comes with reduced assurance for 'filling reservoirs'. Historically the mountain reservoirs were reduced to minimum operating levels on or about Dec 31 and reservoir planners then relied on the building snowpack to fill and in many cases spill. But the historical balance had higher probability for spill than for not filling. With a declining snowpack, planners will have to begin holding additional water in storage in the reservoirs beyond mid-January or at least until a sufficient snowpack develops to help cope with the increased risk of increasingly having to rely on future weather rather than having both a snowpack and the expectation of remaining weather.

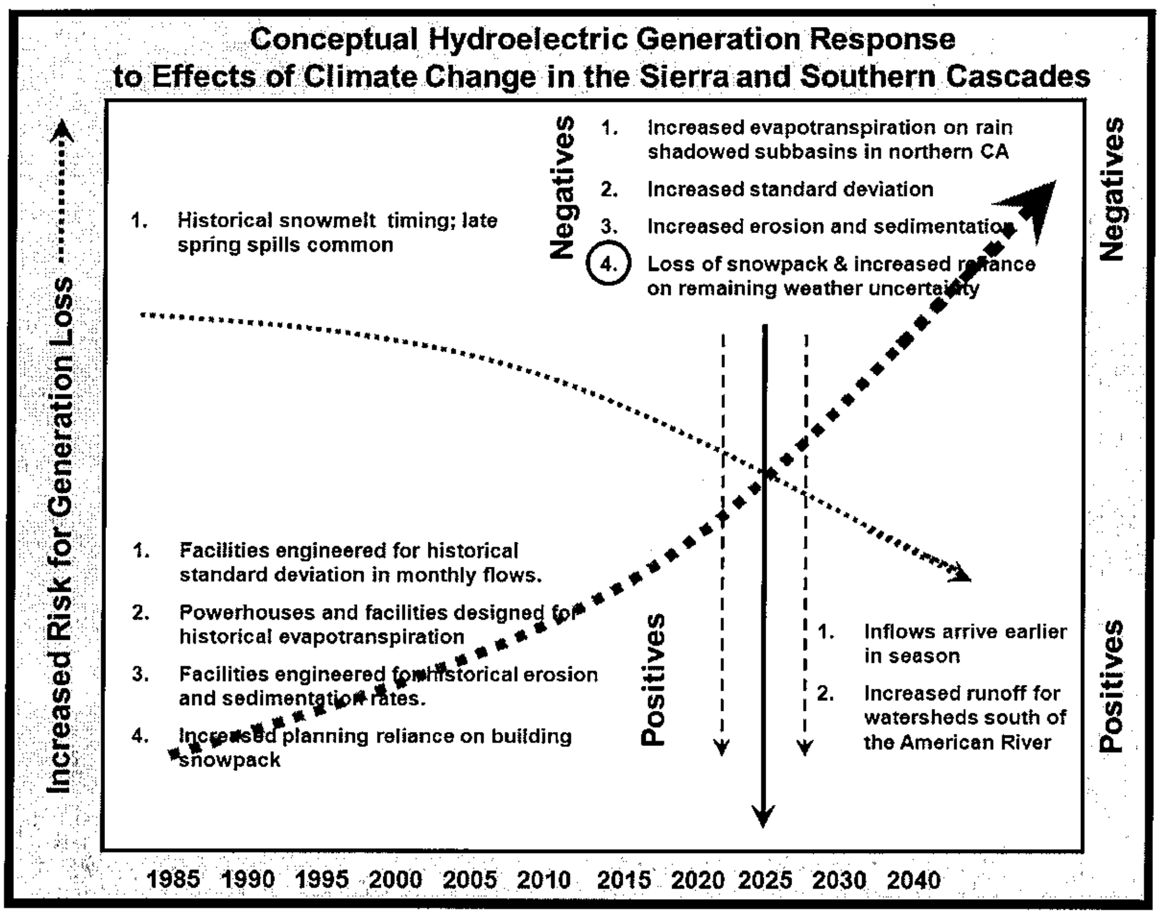


Figure 7. A likely generation response for mountain hydroelectric generation based on the two 35-year period analyzed.

CONCLUSIONS

When a number of large California rivers are compared for two successive 35-year periods, 1942-1976 and 1977-2011, it is apparent that changes indicative of climate change have occurred. In addition to an increasing standard deviation and overall variance in their water year and winter flows, there are trends that indicate a shift in spring flows into earlier months of the year, namely March and February. When grouped into two consecutive 35-year periods beginning in 1942, water year flows from the American River southward have increased since the mid-1970's. There are indications from earlier studies (Freeman, 2011) that warmer air may be capable of holding additional moisture, which when sufficiently cooled as it ascends the windward west facing side of the Sierra may be providing additional opportunity for precipitation increase, much of it in the form of snowfall. It should be noted that from the Yuba River north, the Sierra is lower elevation and less steep. Compared with the Sierra to its south, the Feather River on the northern end of the Sierra is more representative of the older ancestral Sierra. The Feather has maintained its more ancient cut though the Sierra crest eastward well into the Basin and Range Province near Honey Lake. The decline in April through July flow, with consequent increase in March and even February is likely the result of both an earlier snowmelt and an increase in the amount of precipitation which now occurs as rainfall during those two months. Freeman, (2010) showed that on the Feather River in rain shadowed subbasins, minimum winter temperature during storms have increased approximately 6-9 degrees Fahrenheit since 1976. For PG&E with its mountain hydroelectric system in the Sierra, southern Cascade, and Coastal Mountain ranges, its hydro system is sufficiently diverse across different topographic relief and geology that when comparing the two successive 35-year periods, PG&E is currently not seeing any overall change in its system's hydroelectric production that can be directly attributed to climate change. Water year losses in runoff that are occurring from rain shadowed subbasins in northern California, are currently being balanced by earlier inflows to the reservoirs along with an increase in water year runoff from the American River southward in the Sierra. The current "no net change" is anticipated to change in the near future with assumed continued warming. For the relatively small operational subbasin drainages above mountain reservoirs or between diversion dams, orographic cooling of winter and spring storm systems appear to have sufficient cooling effect to slow and somewhat buffer the warming impacts that are otherwise currently being observed on the northern Sierra rain shadowed subbasins such as Lake Almanor and East Branch of the North Fork Feather River.

REFERENCES

Freeman, G.J. 2003. Climate change and California's diminishing low elevation snowpack – a hydroelectric scheduling perspective. Western Snow Conference 71:39-47.

Freeman, G. J. 2007. A program to increase aquifer outflow in northern California's McCloud and Pit River watersheds. Western Snow Conference 75:31-42.

Freeman, G.J. 2008. Runoff impacts of climate change on northern California's watersheds as influenced by geology and elevation – a mountain hydroelectric system perspective. Western Snow Conference 76:23-34

Freeman, G. J. 2010. Tracking the impact of climate change on central and northern California's spring snowmelt subbasin runoff. Western Snow Conference 78:107-118.

Freeman, G. J. 2011. Climate change and the changing water balance for California's North Fork Feather River. Western Snow Conference 79:71-82.

Hill, M. 2006. Geology of the Sierra Nevada. California Natural History Guide Series No. 80. 453 p.

Jefferson, A., A. Nolin, S. Lewis, and C. Tague, 2008. Hydrogeologic controls on streamflow sensitivity to climatic variability, Hydrological Processes, 22: 4371–4385 DOI: 10.1002/hyp.7041 (accessed 7 April 2009).

Koczot, K.M., A.E. Jeton, B.J. McGurk, and M.D. Dettinger, 2005, Precipitation-runoff processes in the Feather River Basin, northeastern California, with prospects for streamflow predictability, water years 1971–97: U.S. Geological Survey Scientific Investigations Report 2004–5202, 82 p.

Knowles, N., M.D. Dettinger and D.R. Cayan, 2006. Trends in snowfall versus rainfall in the western United States, Journal of Climate, 4545-4559.

Mote, P.W., A.F. Hamlet, M.P. Clark, and D.P. Lettenmairer. 2005. Declining mountain snowpack in western North America. American Meteorological Society. January 2005, 39-49

Nadin, E. S. (2007) Structure and history of the Kern Canyon fault system, southern Sierra Nevada, California. Dissertation (Ph.D.), California Institute of Technology.

THE 2014 CALIFORNIA DROUGHT – DEALING WITH EXTREME DRYNESS FROM A HYDROELECTRIC PLANNING PERSPECTIVE

Gary J. Freeman[1]

ABSTRACT

The 2013 calendar year was the driest year on record for California. For San Francisco based Pacific Gas and Electric Company (PG&E), which operates the largest investor owned hydroelectric system in the United States, the water management planning challenges, which were encountered during the first three months of 2014 and the twelve unusually dry months preceding 2014 were unlike those of earlier droughts. The acceptance of both the concept of climate change impacts as well as new paleo-climatological research findings about California and the southwest were for the first time being given serious consideration in the Company's water release planning. The prospect that the persistent high pressure region blocking the storm track into California from the Eastern Pacific and Gulf of Alaska could possibly remain "parked in place" became a principal scenario needed for effective planning. In terms of snow water equivalent (SWE), the February 2014 statewide snow surveys were less than 15% of the historical February 1 average. The demands on downstream water release requirements for maintaining biological flows, whitewater rafting, and other recreational opportunities have continued to increase in the past 38-39 years from the 1976-1977 drought, which were two successive very severe dry years. Conditions leading into the 2014 drought included 15-years of generally declining wetness over much of California causing the northern California's porous volcanic aquifer storage to decline significantly from the aquifer's relatively high mid-1990's storage state. Also water year runoff from rain-shadowed areas of the northern California's Sierra and southern Cascades have been in a state of trending decline since the 1976-1977 drought, a condition likely attributable to impacts from climate change. Utilizing the latest research findings available in 2014 on climate change and drought, the approach to reservoir and power production planning at PG&E changed from that utilized with prior droughts. Rather than assuming median likelihood or some low level of exceedances probability for remaining seasonal precipitation, the planning would take place as if the high pressure system pattern would continue to persist with no additional runoff expected. (Key words: drought, climate change, reservoirs, Sierra, hydroelectric).

INTRODUCTION

On January 17, 2014, following California's twelve driest months on record, the governor of California Edmund G. Brown Jr. declared a statewide drought. This declaration would start the needed processes for drought planning and providing federal aid to impacted businesses, communities, and other affected entities. For Pacific Gas and Electric Company based in San Francisco with the largest investor owned hydroelectric system in the United States, water management operational planning for its mountain reservoirs would require giving consideration to two relatively new concepts, not given serious consideration during earlier 20th century droughts. The first concept that needed planning consideration was some of the new paleoclimatological findings that indicated droughts which had occurred in California prior to the start of climate records in the mid-19th century were both more severe and longer lasting than droughts that occurred during the existing record. The second concept for consideration was to consider that ongoing climate change may have begun to impact the severity and persistence of earlier prerecorded droughts. For effective hydroelectric planning, with a long history of relying on historical time series of unimpaired flows, precipitation, and snowpack data, the concepts of climate change and new climate data becoming available about droughts that occurred prior to the record period would change the water management approach to water release planning. California is located in an area that uniquely defines the Mediterranean climate, having a long dry summer and wet winter and early spring period. The summer dryness is dependent on an area of high pressure

Paper presented Western Snow Conference 2014

[1]Power Generation Department, Pacific Gas &Electric Co., Mail Code N13A, P.O. Box 770000, San Francisco, CA 94177, GJF2@pge.com

shifting northward just west of the California coast deflecting the storm track northward. In the winter with the return of arctic ice and cooling, the blocking high pressure ridge shifts southward and storms can once again enter California from the eastern Pacific. For California, atmospheric rivers (AR's), which typically are relatively warm and semitropical in origin, and therefore have relatively high moisture content and are typically are a major contributor to winter precipitation. The majority of precipitation for California typically comes from 5-6 of these large AR's. On occasion a very large, relatively long duration AR event takes place, an event which has historically been called the 'Pineapple Express'. Some of the notable Pineapple Expresses occurred in February and March 1986, and in the winter of 1998, a year with a strong El Nino. PG&E's reservoir operational planning team gave strong consideration that the high pressure ridge was revealing a strong persistent pattern of "parking", resistant to moving, and consequently not allowing the storm track to enter into California. Beginning in early January, the lack of snowpack and increasing awareness of the persistent high pressure blocking prompted reservoir operators to quickly reduce water releases from most mountain reservoirs. In addition to reducing water releases for hydroelectric production, variances were quickly requested to reduce instream flow releases for biological, recreational, and downstream water use. The process of getting a variance in downstream water releases requires a lengthy review, therefore in order to be effective the variance request process needed to be initiated quickly. Some early February AR's entered into California as the Pacific High shifted slightly southward, however, much of the storm track continued to remain to the far northern part of California and Oregon. By mid-February, the lack of precipitation led to a very shallow snowpack covering the higher elevations in the Sierra and southern Cascades. As with earlier droughts, both the regression and conceptual modeling procedures utilized to forecast seasonal runoff did not consistently provide reasonable results. For PG&E, in which nearly 40% of its historical conventional hydroelectric production comes from northern California's large springs, the continued long term decline in aquifer outflow was best defined by utilizing trending rather than actual modeled prediction. Following 13 months of unprecedented dryness, soil moisture accounting became an important factor for consideration during the first significant precipitation, which occurred in early February. The early February 2014 storms were mostly from relatively warm AR's that brought rainfall rather than snowfall into the medium to higher elevations of the Sierra and southern Cascades. For northern California with its relatively low elevation Feather, Pit, and McCloud Rivers and the Eel River located in the coastal mountain range, soil moisture accounting was an important first step in runoff forecasting and water release planning for reservoir management.

THE YEARS PRECEDING 2014

The years leading up to the late 1900's, especially for northern California's Pit and McCloud Rivers were somewhat similar to the years leading into the 1928-1934 seven year drought. A number of years of below average water year precipitation beginning about 1908 and ending with 1934 resulted in a long term decline in aquifer outflow into the Pit River. The low state in northern California's aquifer storage fully restored itself and again reached a high storage state in 1976. A long term trend downwards from the 1976 'high aquifer outflow state' started in 1977. During the years leading up to 2014, there were three other high aquifer outflow periods, but each less than the earlier aquifer water year outflow. Beginning in in the mid-1970's a relatively steep downward trend in aquifer outflow rate was accompanied by a long term decline in precipitation. In terms of water year precipitation, only the 2006 and 2011 water years were significantly above normal. Hat Creek, a tributary that flows into the Pit River readily shows this long term decline in Figure 1. The aquifer outflow index component is calculated utilizing the minimum daily flows during the fall months of August and September for both the current and prior year. Because the aquifer outflows contain precipitation that had fallen several decades prior to the current year, the natural lag created a moving average of its own with long term trends that appears sensitive to the wet and dry cycles of the Pacific Decadal Oscillation (PDO) which lasts 20-30 years, the El Nino Southern Oscillation (ENSO) which lasts 2-7 years , and other types of recurrent cycles. Once the overall trend starts, the decline or rise is often multi-decadal and the direction that it's headed can be forecasted utilizing trending until a change takes place. Because the trend direction for the aquifer outflows is relatively long lasting, some idea as to what may lay ahead in terms of flows may be inferred. The gradualness of the rises and falls in the outflow rate of the large springs are helpful in predicting approximate flow rate going forward. Approximately 89% of Hat Creek's surface runoff comes from large springs, which provide water that had entered the headwater recharge area several decades earlier in the form of snow- or rain-fall. Once the aquifers in the headwaters have become sufficiently depleted, it may take several years, and possibly decades for the aquifer storage to fully recover depending on future wetness and snowpack which would provide sufficient recharge opportunity. With climate change and the continuing loss of the northern California snowpack (Freeman, 2011, 2012), the recharge opportunity for the aquifers are continuing to decline. Adequate recharge requires both sufficient wetness and precipitation in the form of snow to be effective in terms of slow melt allowing the maximum potential for recharge consistent with infiltration capacity of the soils. One of the concerns with warmer storms containing high moisture is that while they may reach sufficient cooling for producing precipitation through the orographic process when encountering high mountain barriers, there are many areas in northern California that are relatively low elevation and are located behind mountain barriers creating effective rain shadows.

RECENT RESEARCH AND TOOLS FOR DROUGHT PLANNING

Recent research findings for climate change, paleoclimatology, and atmospheric rivers have influenced water management planning at PG&E. Research findings by Ingram, 2013 provide numerous examples of past droughts that were more severe than those experienced in the record period and also examples of those that lasted decades and even centuries in California. Prior to 2013, the period of available record has the 1976 and 1977 water years as being the most severe dry years and the 1928-1934 and 1988-1992 as the two longest periods of consecutive

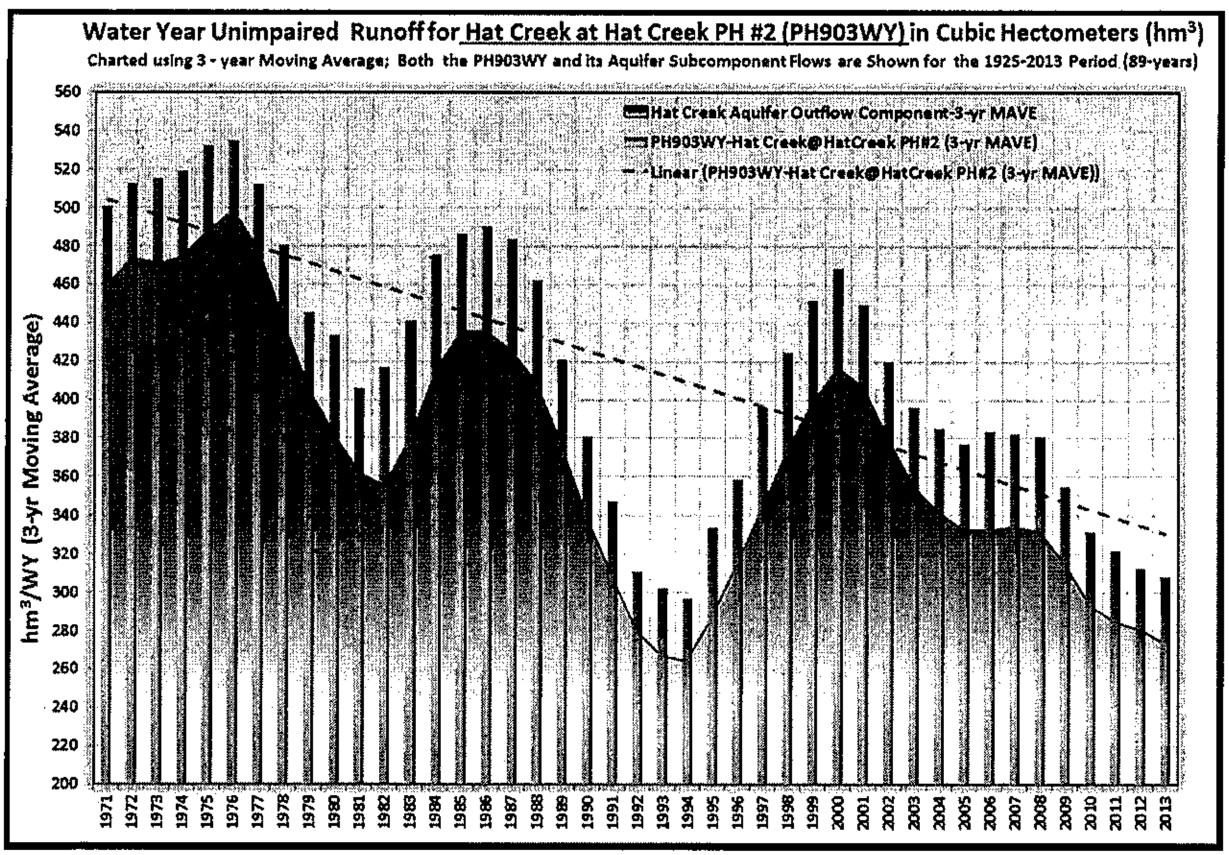


Figure 1. Hat Creek @ Hat Creek PH#2 (tributary to Northern California's Pit River) unimpaired flow including its aquifer outflow component for the period 1971 through 2013. All values are shown with a 3-year moving average.

drought. Knowing that long periods of severe drought were common in California's relatively recent past prepares us to plan for that possibility going forward. With regard to the persistent 'parking' of the Pacific High off of the California coast, the increasing loss of Arctic sea ice and warming of the Arctic may have influenced a slowing of the jet stream's zonal flow with greater amplitude of its waves leading to increased persistence of drought, floods, hot and cold spells (Francis, 2012). Increasing awareness that the persistent high may be caused from climate change led water management planning to become increasingly cautious in expecting a quick change in the pattern. Beginning in early January, water management's operational planning proceeded in a manner that assumed no additional runoff. If wetness returned than the 'little or no water release plan' would change accordingly. Recent research regarding atmospheric rivers increased overall awareness that should 4 or 5 atmospheric rivers occur, the drought could rapidly end and a possible return to normal could take place. However until such wetness happened, the plan would be to operate as if the high pressure ridging would continue to persist and that drought could possibly continue for several years. Moderate atmospheric rivers that occurred during the month of February were each watched closely for their forecasted positioning and whether or not they would be able to shift sufficiently far south to help the drought picture.

HYDROLOGICAL CONDITIONS FOR JANUARY, FBRUARY, AND MARCH 2014

The February snow surveys indicated a statewide snowpack snow water equivalent at only 24% of normal for that date. Even if normal snow accumulation was to occur between the first of February and April 1, the snowpack would only reach 65% of average. Precipitation overall statewide was likewise well below normal with the California Department of Water Resources (DWR) northern 8-station precipitation index indicating only 35% of normal for that time of year. With normal precipitation for the remainder of the season the index could be expected to reach 67% of average. The California Climate Tracker's statewide 12- month January 2013 through January 2014 precipitation shown in Figure 2 shows the past 12 months to be the driest such period on record for California. A growing awareness that this drought was in certain ways different from others experienced during the period of record quickly caught people's attention as requiring a higher level of planning and awareness than has previously been the case. In addition to being very dry, the average January temperatures for the Sierra Region where most of California's water comes from were also the warmest on record. The warm temperatures and general lack of soil moisture had also prompted a statewide fire alert. The expectation was becoming evident that if soil moisture was not restored, vegetation would likely be stressed the following summer with increased fire risk. For Lake Pillsbury, on the Eel River in California's coastal range, after several months with nearly no precipitation the first rains in 2014 required approximately 5.0 inches of soil moisture to be replenished before any significant inflow into Lake Pillsbury occurred. Likewise the first storms in 2014 gave a very limited runoff response in both the Sierra and southern Cascade streams. Figure 3 compares results from the State of California's DWR automated sensor system beginning on 12/31/2013 and displays results at approximate 15-day intervals. While PG&E's mountain lakes overall had almost near normal reservoir levels prior the spring snowmelt freshet, the lack of adequate snowpack for refilling them remained as a major concern. On March 1 most reservoirs did not have sufficient snowpack for filling the reservoirs. In 2014 most of the February and March storms were limited to far northern California and as such did not provide significant precipitation. The persistent high pressure ridge remained parked off the coast of central California, effectively deflecting the storm track into far northern California and into Oregon. Minimum temperatures accompanying storms as shown in Figure 4 have increased in recent years with the January and February minimum temperatures accompanying storms in 2014 being the highest on record for the Canyon Dam Weather Station on the North Fork Feather River.

CONCLUSIONS

The extreme dryness in California for the 2013 calendar year and record January and February high maximum temperatures were unprecedented. The 2014 California drought prompted PG&E's Water Management

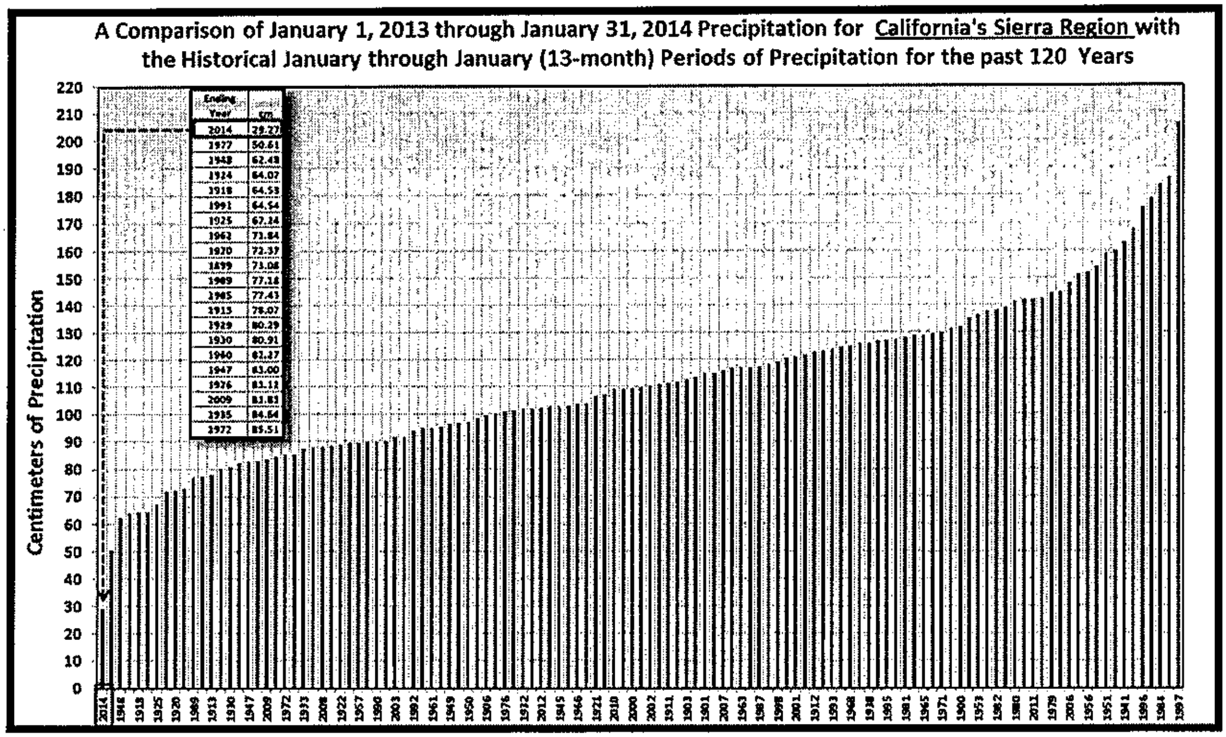


Figure 2. The January 1, 2013 through January 31, 2014 (13-month) period is shown in this chart from the California Climate Tracker as being the driest on record.

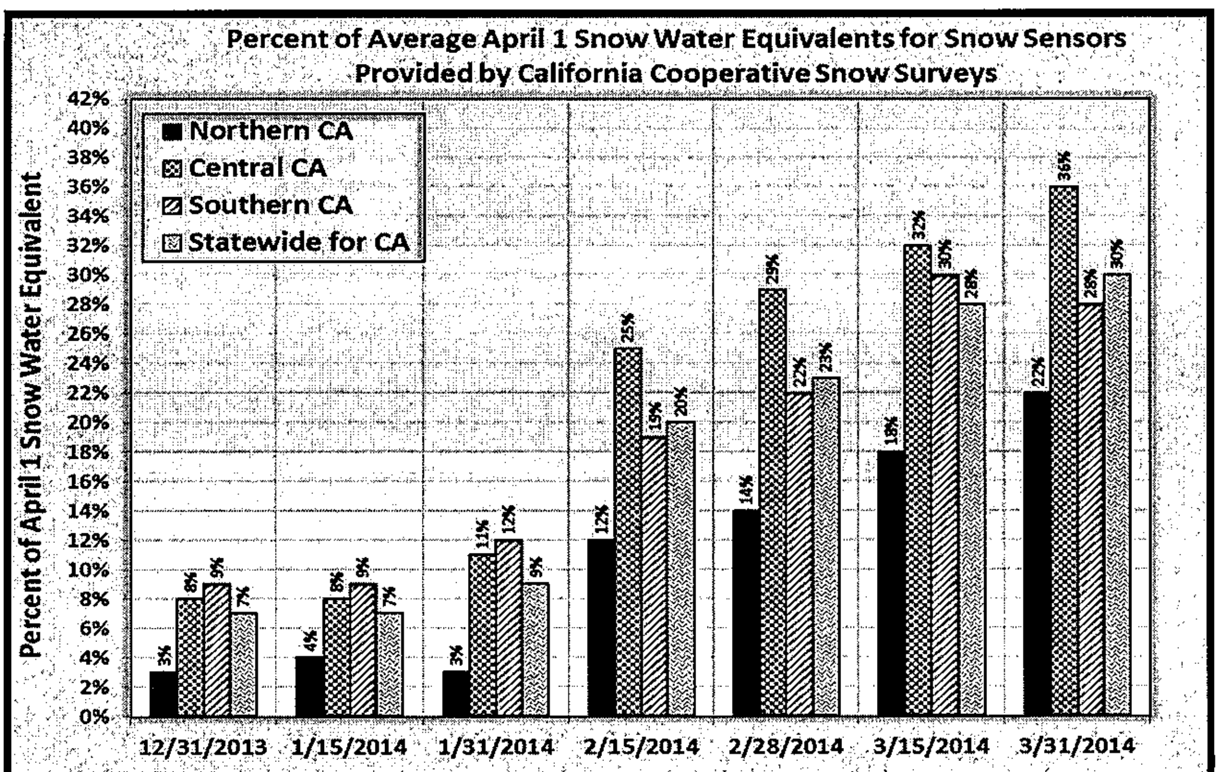


Figure 3. Percentage of average snowpack for the date shown. Data from all automated CDEC sensors statewide.

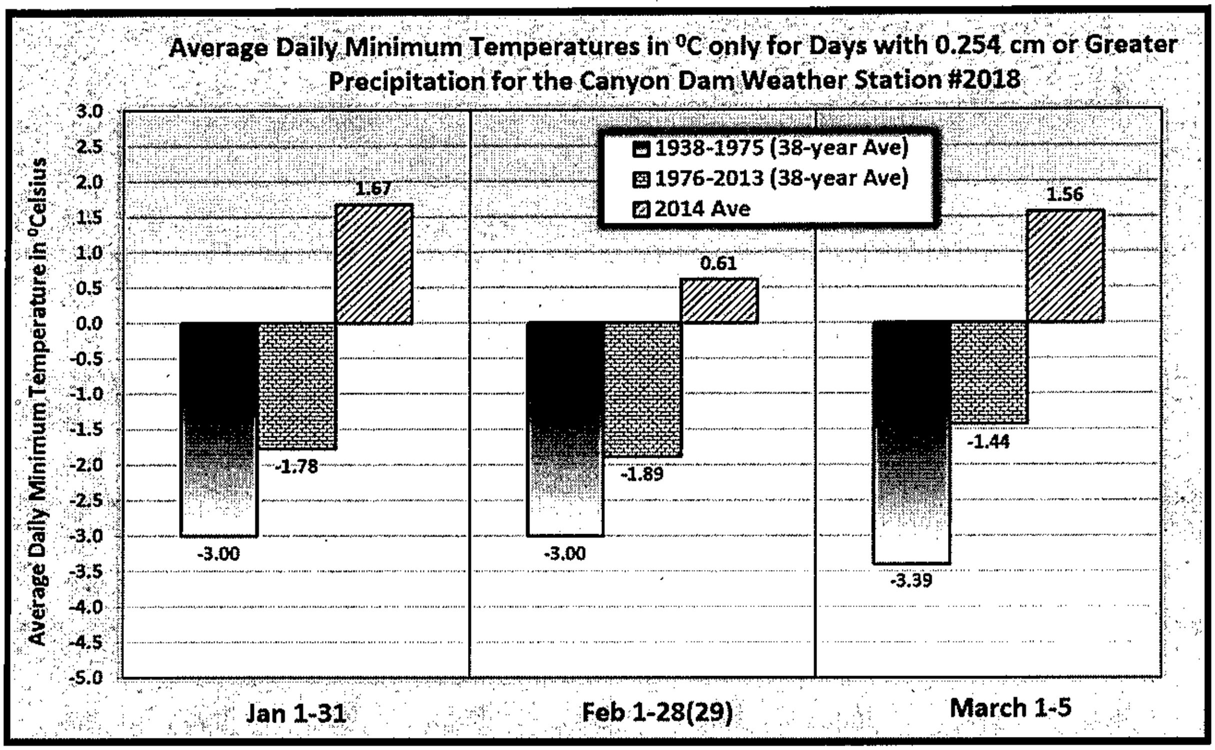


Figure 4. A comparison of two successive 38-year periods with the 2014 January, February and first 5-days in March for minimum temperature only on days with 0.254 cm or greater precipitation.

planning team to take into consideration a number of considerations with special consideration to: 1) recent paleoclimatological findings indicating that droughts lasting decades and centuries have been common and can be expected for California, 2) impacts of climate change may cause unexpected change outside of the recorded record, and 3) the Pacific Decadal Oscillation's current condition needed to be considered as likely having an influence on current drought conditions.

REFERENCES

Francis, J. A. and S. J. Vavrus, 2012: Evidence linking Arctic amplification to extreme weather in mid-latitudes, Geophys. Res. Lett., Vol. 39, L06801, doi:10.1029/2012GL051000.

Freeman, G. J. 2007. A program to increase aquifer outflow in northern California's McCloud and Pit River watersheds. Western Snow Conference 75: 31-42.

Freeman, G. J. 2011. Climate change and the changing water balance for California's North Fork Feather River. Western Snow Conference 79:71-82.

Freeman, G.J. 2012. Analyzing the impact of climate change on monthly river flows in California's Sierra Nevada and southern Cascade mountain ranges. Western Snow Conference 80: 3-14.

Ingram, B. L., F. Malamud-Roam, 2013. The west without water. University of California Press. 289 p.

ATTACHMENT 4

State Water Resources Control Board

Alan C. Lloyd, Ph.D.
Agency Secretary

Division of Water Rights
1001 I Street, 14th Floor ♦ Sacramento, California 95814 ♦ 916.341.5300
P.O. Box 2000 ♦ Sacramento, California 95812-2000
Fax: 916.341.5400 ♦ www.waterrights.ca.gov

Arnold Schwarzenegger
Governor

January 12, 2006

To Individuals on Service List for P-2105:

TRANSMITTAL OF EIS COMMENT LETTER (FERC NO.2105-089)

This letter transmits the State Water Resources Control Board (State Water Board) comment letter, filed with the Federal Energy Regulatory Commission (FERC) on the final Environmental Impact Statement issued for relicensing of the Upper North Fork Feather River Project (FERC No. 2105). The comment letter along with an enclosure document has been posted to the FERC online e-library as submittal 20060111-5208. The filing may be accessed at FERC's website through the following link: http://elibrary.ferc.gov/idmws/search/fercgensearch.asp

In accordance with FERC Rules of Practice and Procedure, State Water Board staff serves this copy of the letter for your records. This mailing does not include the technical document that was enclosed with the comment letter. You may review and download the referenced document from the FERC posting, or you may obtain a hard copy upon request by contacting me at sstohrer@waterboards.ca.gov (please identify "Project 2105 - Willow Flycatcher" in the subject line).

Sincerely,

Sharon Stohrer

Sharon Stohrer
Environmental Scientist

with state and federal water quality standards by setting conditions of water quality certification as necessary to protect the beneficial uses along with requirements for monitoring and reporting to demonstrate adequate response to those protection measures.

With a focus toward Clean Water Act compliance, State Water Board staff offers the following comments on specified subjects with the hope that this will provide insight for the Commission and will aid that body in their decision-making.

Anadromous Fish Passage

The Commission invited comment on final EIS analyses and conclusions associated with the Modified Section 18 Fishway Prescriptions and Section 10(j) Terms and Conditions filed by NOAA Fisheries on March 14, 2005. State Water Board staff appreciates this opportunity, but recognizes the December 12, 2005 amendment to withdraw the fishway prescriptions and 10(j) recommendations at this time. NOAA Fisheries clearly reserves its right under section 18 of the Federal Power Act and requests an explicit license reopener on the issue of fish passage that may be exercised if certain events fail to materialize. State Water Board staff elects to make no comment on this matter today. However, if the Commission finds that a license reopener must be exercised and future section 18 prescriptions are filed on the Project No. 2105 license, State Water Board staff requests the legitimate option to provide comment on the terms and conditions filed by NOAA Fisheries at that time.

Water Temperature

The Basin Plan designates a beneficial use of cold freshwater habitat for both Lake Almanor and the NFFR, along with a coldwater spawning designation for the NFFR. The NFFR below Lake Almanor is currently proposed for temperature listing on the United States Environmental Protection Agency's (U.S. EPA) section 303(d) List of Water Quality Limited Segments in the State of California. Water temperature impairments are identified as the "pollutant" of concern, and must be addressed.

In its EIS, the Commission evaluates effects of continued project operation in accordance with a proposed "staff alternative." The staff's alternative (and subsequent *Recommended Alternative*) modifies the existing project with measures that are expected to improve some environmental and recreational resource conditions, but fails to include a future operational program with actions that will moderate water temperatures in the NFFR to effectively protect the cold freshwater habitat uses downstream of the Caribou Powerhouses. Although the Recommended Alternative (EIS, section 5.1.4) incorporates a proposed flow regime consistent with provisions of the partial Settlement Agreement[3] (S.A., Tables A-1 and A-2, Appendix A), this partial agreement clearly acknowledges the unresolved nature of water temperature issues (S.A. pages 6 and 19). A flow regime consistent with Table A-2 was not designed to moderate water temperatures in the Belden reach and will likely result in exacerbation of the thermal conditions of that diverted reach as summer flows are reduced by up to 46% from the existing condition (140 cfs) in Critically Dry and Dry water year types. State Water Board staff respectfully disagrees with analysis and conclusions described (EIS, pages 3-111 through 3-113) on water temperature response expected in the Belden diverted reach with implementation of minimum flows described above.

State Water Board staff supports the Commission's conclusions regarding potential thermal relief that may be recognized with increased releases from the Canyon Dam low-level outlet in July and August (EIS page 3-78). This measure in combination with other measures may have the potential to improve cold freshwater habitat downstream while maintaining habitat conditions in Lake Almanor. State Water Board staff suggests that other reasonable options for achieving seasonal water temperature relief in the Belden reach and downstream reaches of the NFFR have been dismissed without adequate analysis and justification. Potential measures for minimizing thermal impacts to the Belden reach and the NFFR watershed downstream will be developed and analyzed for effectiveness and incidental environmental impacts in the State's California Environmental Quality Act (CEQA) compliance efforts. The CEQA process parallels the National Environmental Protection Act (NEPA) process, and may introduce additional new mitigation alternatives that could resolve the water temperature impacts of Project No. 2105 on the NFFR watershed.

The State Water Board is currently in the process of developing an Environmental Impact Report (EIR) for compliance with CEQA. The EIR is expected to provide full disclosure of potential project-related impacts and the analyses to support issuance of the 401 water quality certification on the relicensing of Project No. 2105. On a nationwide conference call between Commission staff and various state certifying agencies for water quality (December 1, 2005), Commission staff promoted coordination between state and federal agencies in the development of CEQA and NEPA documents. State Water Board staff is encouraged by the Commission's cooperative approach and suggests that prior to filing with the U.S. EPA and adoption of the final EIS (40 C.F.R. §1506.3[a]), the Commission should consider the merits of information that may be presented in the State's EIR.

Willow Flycatcher Habitat

Discussions provided in the Upper North Fork Feather River Project Application for New License (Vol. II, page E-3.2-23 – 24) regarding Willow Flycatcher (*Empidonax traillii brewsteri*) report no records of this species in the immediate vicinity of Lake Almanor. The

[3] PG&E. 2004. Project 2105 Relicensing Settlement Agreement; Upper North Fork Feather River Project, FERC Project No. 2105.

discussion suggests the existence of limited suitable habitat within the Project No. 2105 boundaries, and states these areas will not be impacted by continued operation of the project. This information fails to disclose known Willow Flycatcher breeding pairs and seasonally occupied habitat documented through surveys conducted by the Point Reyes Bird Observatory Conservation Science team (PRBO)[4,5]

Regarding Willow Flycatcher, the terrestrial resources section of the EIS (page 3-166) incorrectly states that suitable large stands of willow habitat are not found in the project area, making it unlikely that the species occurs here. Commission staff should consider the new and substantive information provided in the 2003 PRBO songbird monitoring report (Enclosure) and develop a Supplement to the EIS as necessary, pursuant to the requirements at 40 C.F.R. §1502.9[c][1].

During 2003 Willow Flycatcher surveys in wet meadows within the Project No. 2105 boundaries, PRBO biologists detected 13 breeding bird territories on the southwest shore of Lake Almanor and six on the northwest shore. These wetland locations are recognized as important strongholds for this State endangered species. Willow Flycatcher habitat along the shore of Lake Almanor is dependent on favorable water levels suitable to maintain the wet meadow conditions. State Water Board staff recommends that Commission staff analyze the effects of lake level on the sustainability of Willow Flycatcher habitat, including the direct influences of water surface elevation on local, unconfined aquifer water levels. A scientifically supported analysis of potential impacts (negative and beneficial) from the Recommended Alternative must be disclosed, and measures proposed as necessary to maintain or enhance Willow Flycatcher habitat qualities along the margins of Lake Almanor. A monitoring program and future adaptive management opportunities should be provided.

State Water Board staff recommends that the Commission's determination on completeness of the NEPA findings wait to consider data, analyses and conclusions that will be provided in the State's EIR. The draft EIR will identify feasible mitigation for any impacts to water quality that result from controllable factors resulting from project operation or proposed project alternatives. This environmental document may include innovative alternative proposals for mitigation of thermal effects of the project and it is expected that issues associated with Willow Flycatcher habitat will be introduced in the draft EIR.

---

4 Humple, D.L. and R.D. Burnett. 2004. PRBO Songbird Monitoring in Meadow and Shrub Habitats within Lassen National Forest: Results from the 2003 Field Season; Progress Report to the U.S. Forest Service. (PRBO Conservation Science, Contribution Number 1173.)

5 Burnett, R.D., D.L. Humple, T. Gardali, and M Rogner. PRBO Avian Monitoring in Lassen National Forest: 2004 Annual Report. (PRBO Conservation Science, Contribution Number 1242.)

ATTACHMENT 5

Society & Natural Resources, 13: 185–202, 2000

0894-1920/00 $12.00 +.00

Tourism Dependence in Rural America: Estimates and Effects

DONALD B. K. ENGLISH

USDA–Forest Service
Southern Research Station
Athens, Georgia, USA

DAVID W. MARCOUILLER

Department of Urban and Regional Planning
University of Wisconsin–Madison/Extension
Madison, Wisconsin, USA

H. KEN CORDELL

USDA–Forest Service
Southern Research Station
Athens, Georgia, USA

Recreation and tourism development continue to play an important role in reshaping rural America. Efforts to evaluate the effects of such development are complicated because residents and nonrecreation visitors also use the businesses that are affected by recreation and tourism visitors. We present a method for estimating in nonmetropolitan counties jobs and income that are generated by recreation and tourism visitors from outside the county. Several different techniques are used to (1) cluster similar counties, (2) account for the portion of tourism sector employment that serves local residents, and (3) account for the portion of export activity that serves nonrecreation visitors. Finally, we address the consequences of recreation dependence in rural counties. The counties most dependent on nonlocal tourism activity are compared to other rural counties on income, population, economic structure, and housing variables.

Keywords economic structure, minimum requirements, nonmetropolitan counties, recreation dependence, rural development, tourism dependence

Natural resources provide the amenity base for a rising level of tourism in rural America. Over the past 50 years, many amenity-based rural communities have shifted from an economy based on manufacturing to one driven by retail and service sectors. Tourists seeking natural resource–based settings, tranquility, and adventure have affected rural economies by injecting new dollars into local businesses, supporting local tax bases, and creating increased demands for locally available land, labor, and capital. With regard to recreational use of natural resources, tourist expenditures create local demands for traded goods and services, thus creating jobs

Received 12 May 1998; accepted 29 March 1999.
Address correspondence to Dr. Donald B. K. English, Forestry Sciences Lab, 320 Green St., Athens, GA 30602, USA. E-mail: Don.English@srs_athens.fs.fed.us

and income for local residents (Johnson and Moore 1993; English and Bergstrom 1994).

However, the quality of life in such rural communities is often a point of contention between long-time residents and newcomers, especially as communities become very dependent on tourism (Rothman 1998; Green et al. 1996). Whether the change to increased dependence on recreation and tourism has been beneficial is a tricky empirical question. Many key socioeconomic issues related to tourism development remain unanswered. For example, what is the relation between recreational land use and local tourism business activity? How does tourism affect the level or distribution of residents' income in heavily impacted communities? Such questions are the basis for discussing public policy effectiveness in land management and community development.

Public agencies at all governmental levels are concerned with the answers to these and similar questions. An outgrowth of this concern is that the effects of land management decisions on resource-dependent rural communities are incorporated explicitly in the planning processes of these agencies (USDA–Forest Service 1995). Unfortunately, evaluating the rural development consequences of management efforts related to natural resource-based tourism can be somewhat difficult. Many of the businesses that cater to tourists also serve local residents, thus making it difficult to determine how much economic activity is directly due to nonresident visitors.

Although tourism is rather ill-defined from an industrial perspective (Leiper 1979, 1990; Smith 1987), geographers and regional economists have developed workable definitions that allow secondary data to be used in assessing tourism dependence (Johnson and Thomas 1990; Brown and Connelly 1986; Leatherman and Marcouiller 1996a). Most expenditures made by tourists fall into one of four economic sectors: lodging (including hotels, motels, campgrounds, and inns), eating/drinking (restaurants and bars), retail (grocery stores, gas stations, and gift shops), and recreation services (ski areas, golf courses, and amusement parks). In rural areas near large public land holdings, it is not uncommon for a large portion of the economic activity in these sectors to be caused by tourists and other visitors to the area. Given that recreation-based nonmetropolitan counties have experienced three times the rate of net migration as compared to nonmetropolitan areas as a whole (Beale and Johnson 1998), rural communities endowed with natural amenities will likely experience growing local demands on service and retail businesses.

A key difficulty with defining the level of dependence on resource-based tourism is that standard sector aggregates combine receipts from residents with those originating from nonlocal (or export-base) visitors. Certainly, some of the jobs and income in these sectors result from spending by local residents. Some also result from spending by visitors on trips for purposes other than resource-based tourism, such as for business, or for family matters. It is not always easy to determine what proportion is due to tourism, since visitation figures are typically unavailable or unreliable. Separating amenity-based (or recreational) travel from resident spending or business travel is a critical step in estimating usable causal relationships between local natural amenities and tourism dependence.

Also, the type of tourism in rural areas across the United States exhibits wide variation. Activities range from nature-based tourism characterized by guides and outfitters (such as that surrounding the Boundary Waters Canoe Area) to highly developed recreational services and amusements (such as around the Wisconsin Dells). The economic characteristics of tourism along this spectrum need to be incorporated into analyses of tourism dependence.

In this article, we test some sociodemographic hypotheses with respect to nonmetropolitan counties that are generally more dependent on resource-based tourism. We present estimates of the amount of economic activity caused by nonresident recreation and tourism visitors to rural counties in the United States, and compare counties that are most dependent on these visitors to counties that are not for several measures of income, economic structure, housing, and population characteristics. In defining recreation and tourism dependence, we extend traditional methods to focus only on the amount of economic activity in recreation and tourism sectors that is due to nonresident tourism demand. That is, we discount the economic activity generated both by local residents and by nonresidents who travel for purposes other than resource-based tourism. Further, we link this tourism dependence with components of economic structure relevant to discussions of local community development.

Defining Recreation Dependence

Researchers at the U.S. Department of Agriculture (USDA) Economic Research Service (ERS) developed a typology of nonmetropolitan counties in the United States for use in policy analysis, and described their economic dependencies (Bender et al. 1985; Hady and Ross 1990). Initially, the typology used included eight classes of rural policy counties: agriculture, federal lands, government, manufacturing, mining, poverty, recreation, and retirement. However, because only 63 counties were classified as recreation dependent, this category was dropped from further analysis (Ross and Green 1985). In these efforts, recreation dependence was defined as having at least 10% of total employment or labor/proprietor income in eating/drinking places, hotels and other lodging, and amusement establishments.

More recently, Beale and Johnson (1998) used another method to define recreation-dependent nonmetropolitan counties. This work confirmed earlier research (Johnson and Beale 1994) that suggested population growth was noticeably higher in areas with greater levels of recreation resources. Several indicators were used to define dependence. The first was if a county was at least two-thirds of a standard deviation above the national mean on any two of three measures: (1) percentage of employment in 1980 in entertainment, recreation, and personal services; (2) percentage of earnings income in 1980 in amusement, recreation, and lodging; or (3) percentage of housing units in 1980 that were vacant and held for recreation, seasonal, or occasional use. The second measure was if per capita spending on hotels, motels, trailer parks, and camps exceeded $100 in 1982. Individual examination of counties that qualified on either measure ensured that only those with documented recreation resources were retained. This process identified 285 counties as recreation dependent, with geographic concentrations in New England and upstate New York, near the Ozarks, the southern Appalachians, and in the West. Other concentrations occurred in nonmetropolitan coastal counties and the upper Great Lakes.

Beale and Johnson's approach improved on the ERS method by broadening the array of structural economic components, and including a more flexible set of criteria for determining the dependence threshold. However, neither method distinguished among various sources of demand that generated the levels of economic activity which classified a county as recreation dependent. Other USDA initiatives have attempted to develop local indices of amenity presence (Kusmin et al. 1996) and explain amenity migration (Nord and Cromartie 1997). In those two efforts, amenity indices were constructed based on climate, topography, water resources, and other amenities.

The approach reported in this article builds directly upon these previous efforts, but extends them to more closely estimate the effects of nonlocal recreational spending. Extensions include identifying like resource-based regions and applying an export-base estimator known as minimum requirements. Cluster analysis on primary resource-based factors allows more clear specification of tourism type. Applying minimum requirements leads to a more specific estimate of the nonresident component of service and retail sector activity than is found in either the Beale and Johnson or the Kusmin et al./Nord et al. approaches. To clarify the relation of our approach to previous work, it is useful to review the conceptual framework for this type of research.

Conceptual Model

Rural development research treats recreation and tourism as export activities (Dawson et al. 1993; English and Bergstrom 1994). That is, economic growth and development comes from increases in "exporting" goods and services to nonresident visitors. The effects of local demand are generally discounted as representing only transfers of money within the economy. Thus, tourism dependence should be defined with reference to export employment. Therefore, total employment (E) in a county in a tourism-related sector equals employment that serves local demand (E_L) plus employment that serves export demand (E_X). However, visitors to the county on nontourism trips also spend money in tourism-related businesses such as for hotels and food. Many such nontourism trips are for either family purposes or for business travel. Dwyer and Forsyth (1997) refer to travel for meetings, incentives, conventions, and exhibitions—or "MICE" travel. Thus, E_X can be subdivided into a tourism demand component (E_T), and a nontourism demand component (E_N).

Since E_T is employment that serves only tourism-related demand, we assume that E_T depends exclusively on the total number of nonresident tourist trips taken to the county. The number of tourist trips to a county or other destinations is explainable primarily by the set of natural and cultural amenities located there (Stynes and Peterson 1984). On the other hand, nontourism employment (E_N) depends solely on nontourism trips, and so must be explained by characteristics other than resource amenities. In this study, we assume that county population is the primary determinant of the volume of family-related trips. Some research has shown a direct link between population and employment for nonmetropolitan counties (Duffy-Deno 1998). We extend this link and posit a direct relationship between business-related trips and population. Measures of tourism dependence should be based on E_T. Removing the effects of both residents (E_L) and nontourism travel (E_N) allows the identification of the true relationship between tourism dependence and the social, economic, and quality-of-life issues that are important to policy makers and researchers.

Therefore our conceptual model is:

$$E = E_L + E_X$$

$$E_X = E_T + E_N$$

$$E_T = f(\mathrm{REC})$$

$$E_N = g(\mathrm{POP})$$

where POP is the county population and REC is a vector of recreation/tourism attributes for the county.

Methods

This study was limited to the 2261 nonmetropolitan counties in the contiguous United States. To account for structural differences in county size, climate, and other factors, some regional grouping for counties was desired. Because this research was designed to serve the Forest Service's Resource Planning Act (RPA) Assessment process, rural counties were divided into administrative regions used in the RPA Assessment reporting. Three regions were defined: South (VA to OK), North (MD, MN, and IA to New England), and West. Separate but identical analyses were carried out for each region to determine E_T. The South region contained 955 rural counties, the North region contained 686, and the West region contained 620.

Total employment and income data for four tourism-related sectors were extracted from sectoral data in the 1993 Micro-IMPLAN data set, developed by the Minnesota IMPLAN Group. These sectors included (1) hotels and other lodging, (2) eating and drinking places, (3) recreation and amusement services, and (4) other retail trade. Visitor spending in these sectors typically accounts for the majority of expenditures used in studies of the impacts of recreation and tourism (Dawson et al. 1993; Johnson and Moore 1993).

Estimating Export Employment in Tourism-Sensitive Sectors

The minimum requirements technique was used to separate E_L from E_X for each sector. Minimum requirements assume that local production serving local demands occurs prior to producing for exports (Pratt 1968; Isserman 1980), so a sector develops first to meet the needs of the local populace. Other assumptions are that counties can be divided into homogeneous groups, and that counties in the same group will have similar economic structures, in that the proportion of activity that serves local demand will be fairly constant within the group.

Cluster analysis was used to group counties in each region that were similar with respect to population density, distance from metropolitan areas, and the proportion of county acres in each cropland, forests, pasture/range, and mountains. Eight clusters were retained for each region. Within each cluster of counties, the minimum percentage of economic activity in each tourism-related sector was identified. Under minimum requirements, it was assumed that this is the percentage of employment needed to meet local demand. Thus, in the county with the minimum employment percentage, there is no "export" to support demand by nonresidents. In all other counties in the cluster, the excess above the minimum percentage serves export (out-of-county) demand. The calculation to determine export employment[1] for county i and sector j was:

$$\mathrm{EX}_{ij} = \left[\frac{\mathrm{ec}_{ij}}{\mathrm{ec}_{iT}} - \min\left(\frac{\mathrm{ec}_{ij}}{\mathrm{ec}_{iT}}\right)\right]\mathrm{ec}_{iT}$$

where EX_{ij} is the export employment share for county i and sector j; ec_{ij} is economic activity (employment or income) for sector j in county i; ec_{iT} is economic activity for county i, summed over all sectors; and min(·) is the minimum function, identifying the minimum value for all counties in the cluster of county i.

Estimating the Recreation Component of Tourism-Sector Exports

Results from minimum requirements calculations yielded estimates of E_X. Established techniques do not exist to separate E_T from E_N. Nor are data on the volumes of tourism and non-tourism trips to rural counties readily available. Consequently, we used results from a regression analysis to separate tourism-related export employment from nontourism export employment. The model estimated was:

$$\mathrm{EX}_{ij} = \alpha_j + \beta_{\mathrm{POP}j}\mathrm{POP}_i + \beta_{\mathrm{REC}j}\mathrm{REC}_i$$

where POP is the population of county i; REC_i the vector of recreation/tourism attributes for county i; and α_j, $\beta_{\mathrm{POP}j}$, and $\beta_{\mathrm{REC}j}$ the parameters to be estimated for sector j.

The equation represents the position that total export employment in tourism-related sectors is a function of tourism and nontourism (family and MICE) visitation. County population served as a proxy for the amount of nonresident nontourism trips. A wide array of recreation and tourism attributes was identified as having the potential to explain tourism visitation and hence employment.

There were too many resource attributes to include all of them in the regression analysis, and it was not known a priori which attributes would be most important. We used principal components analysis (PCA) to reduce the resource array into a smaller set of resource factors. To impose an initial structure on the array of resource attributes, each was assigned to one of four groups that represent specific types of opportunities for recreation and tourism (Table 1). Urban resources include developed opportunities that grow with population, such as golf courses, museums, and amusement parks. Land resources include resources that support traditional outdoor recreation activities, such as hiking or camping. Water resources are those that support water-based activities, such as boating, fishing, and swimming. Winter resources are those that support winter activities such as skiing and snowmobiling. PCA factors with eigenvalues greater than 1.0 were retained. In each region, 16 factors were retained, 4 that described urban resources, 6 for land resources, 4 for water resources, and 2 for winter resources.[2] Factors were nearly identical across the three regions.

The principal component factor scores served as the vector of recreation/tourism variables for the regression model. In turn, these scores would be used to predict the level of tourism-dependent employment in each nonmetropolitan county. A log-linear specification for the regression model had the conceptual advantage that predicted values would all be positive. It turned out to provide superior fit to the data as well.

Results of the regression model were used to estimate the amount of export employment that was due to recreation and tourism. The total expected amount of export employment, E_X, was given by:

$$E[E_X] = \exp\,(\hat{\alpha} + \hat{\beta}_{\mathrm{POP}}\mathrm{POP} + \hat{\beta}_{\mathrm{REC}}\mathrm{REC})$$

That is, the total expected amount of export employment in a tourism-related sector was assumed to be a function of the population and recreation resources in a county and of the estimated parameters. All of the recreation resource factors were assumed to contribute only to tourism-related trips, and therefore tourism-dependent employment. Population was used to account for nontourism trips.

Hence, the expected amount of employment caused by nontourism trips was given by:

$$E[E_N] = \exp(\hat{\alpha} + \hat{\beta}_{POP}\,\mathrm{POP})$$

The proportion of export employment due to nontourism-generated trips would be $E[E_N]/E[E_X]$. Therefore, $1 - (E[E_N]/E[E_X])$ would be the proportion of export employment that is dependent on recreation and tourism. That is,

$$E[E_T] = E_X\left(1 - \frac{E[E_N]}{E[E_X]}\right)$$

Characteristics of Counties Dependent on Resource-Based Tourism

How do the rural counties that are most dependent on tourism compare with other rural counties? This question was examined through a series of simple (OLS) regression models. Independent variables in the models included an indicator variable for dependence on recreation, one for adjacency to a metropolitan area, and two more that indicated location in either the Southern or Western portions of the country. Initially, region-dependence interactions were included, but these were nonsignificant and were therefore deleted. Several variables related to population, income, age, education, housing, and economic structure were examined to evaluate the effect of tourism dependence on local residents and their quality of life.

Empirical Results

Regression Results

In total, 12 regression models (4 sectors for 3 regions) were estimated. Table 2 summarizes the results and indicates which resource factors had significant coefficients in predicting export employment by region and economic sector. All of the resource factors were significant in at least 2 of the 12 models. In the West region, at least 3 of the urban-related resource factors were significantly related to export employment in each of the 4 sector models. At least 2 urban resource factors were significant for each sector in the North region models, and for all but the lodging sector in the South region. Most of the land resource factors were tied to export employment in the lodging and retail trade sectors in the North and to the eating/drinking sector in the South and West. Water resource factors were significant in all 4 sectors in the North, all but lodging in the South, but to none of the sectors in the West. Both winter resource factors were significantly related all 4 sectors in the North, and to eating/drinking and recreation services in the West.

Local Jobs and Income Dependent on Resource-Based Tourism

Across all four tourism-related sectors, we estimated that 767,000 jobs result from nonresident recreation and tourism trips to nonmetropolitan counties (Table 2). These jobs account for $11.8 billion in income to employees and business owners. Over $4 billion in income accrues to people in rural counties in both the North and West regions, and about $2.6 billion in the South. Across all rural counties, about

TABLE 1 Definitions of Variables Used in Principal Components Analysis

Urban facilities:	Water resources:
Number of parks and recreation departments	Number of marinas
Number of tour operators + sightseeing tour operators	Number of canoe outfitters + rental firms + raft trip firms
Number of playgrounds + number of recreation centers	Number of diving instruction or tours + snorkel outfitters
Number of private + public swimming pools	Number of guides services
Number of private + public tennis courts	Number of fish camps + private/fish lakes, piers, ponds
Number of organized camps	American Whitewater Association total whitewater river miles
Number of tourist attractions + number of historical places	Designated Wild and Scenic River miles: total 1993
Number of amusement places	National Resources Inventory (NRI) acres in water bodies 2–40 acres, <2 acres, ≥40 acres (lake or reservoir)
Number of fairgrounds	NRI acres in streams <66 ft wide + 66–660 ft wide + ≥1/8 mi wide
Number of local or county parks	NRI water body ≥40 acres (bay, gulf, estuary)
Number of private + public golf courses	NRI wetland acres
Number of ISTEA funded greenway trails	Nationwide Rivers Inventory total river miles, any outstanding value
Estimate of acres of urban/built up land from 1995 National Resources Inventory (NRI)	
Land resources:	Winter resources:
Number of guides services	Cross-country Ski Areas Association number of XC ski firms + public XC centers
Number of hunting/fishing preserves, clubs, lodges	International Ski Service skiable acreage
BLM public domain acres	Federal land acres in counties with >24 in snowfall
Acres of mountains	Agricultural acres in counties with >24 in annual snowfall
Acres of cropland, pasture, rangeland	
USDA–Forest Service National Forest and Grassland acres	
FWS refuge acres open for recreation	
Woodalls number of private campground sites	
Woodalls number of public campground sites	
NPS federal acres	
NRI estimate of forest acres	

TABLE 1 Continued

Acres managed by Bureau of Reclamation, Tennessee Valley Authority, Corps of Engineers	Acres of mountains in counties with >24 in annual snowfall
Total rail-trail miles	Acres of forestland in counties with >24 in annual snowfall
State park acres	
The Nature Conservancy acres with public access	
National Wilderness Preservation System acreage: total 1993	

Note. BLM, Bureau of Land Management; FWS, Fish and Wildlife Service; NPS, National Parks Service; NRI, National Resources Inventory; XC, cross-country. From USDA–Forest Service (1997).

TABLE 2 Summary of Regression Results Predicting Export Employment in Tourism-Related Sectors: Resource Factors With Significant Unstandardized Regression Coefficients, by Region and Economic Sector

General resource factor description	Sector			
	Lodging	Eat/drink	Retail trade	Recreation services
Urban:				
1. Tennis, golf, museums		N, S, W	S	S, W
2. Amusement parks, cultural attractions	N, W	N, W	N, W	N, W
3. Swimming pools, urban trails	W	N, W	W	S, W
4. Local parks, camps, fairgrounds	N, S, W	S, W	N, S, W	N, S, W
Land:				
1. Forest Service lands, wilderness	N, S	S, W	N, S, W	N, S
2. Private forest land	N	S	N	N
3. National Park Service, Fish and Wildlife Service	N	S, W	N	
4. Public campgrounds, other federal lands	S	S, W	S	
5. State parks and forests	W	W		
6. Hunting clubs, agricultural lands	N	W	N	N
Water:				
1. Fishing opportunities, river guides			S	N, S
2. Whitewater rivers	N	N	N	N, S
3. Marinas, lakes		N, S		
4. Ocean, wetlands		S	N	
Winter:				
1. Downhill and cross-country skiing	N	N, W	N	N, W
2. Forest and agricultural land with snow	N	N, S, W	N, W	N, W

Note. N, coefficient significantly different from zero for regression model for the Northern region. S, coefficient significantly different from zero for regression model for the Southern region. W, coefficient significantly different from zero for regression model for the Western region.

300,000 jobs and $3.455 billion in income in the eating/drinking sector are attributable to resource-based tourism. That equals about one-fourth of the total economic activity in that sector in nonmetropolitan counties. Likewise, the 171,000 jobs and $2.366 billion in income in retail trade caused by resource-based tourism comprise about 25% of all jobs in that sector in nonmetropolitan counties. Clearly, resource-based recreation is important to these sectors. For these two sectors, each job generates about $12,000 in income. The level of income per job is low most likely because a significant proportion of these types of jobs are part-time. In the accommodation and recreation services sectors, tourism "exports" account for almost twice as high a proportion of the total activity, over 40%. In addition, income per job is over $20,000 in these sectors.

In some rural counties, there was no economic effect from nonresident recreation. In others, over half of all jobs and income are tied to the tourist industry. Across the country, jobs and income generated by recreation "exports" make up about 3.1% and 1.5%, respectively, of all jobs and income in nonmetropolitan counties. However, these percentages are not the same for all regions. In the South, less than 2% of all jobs and under 1% of income in nonmetropolitan counties are due to nonresident tourism. Rural counties in the West are far more dependent on tourism. Jobs serving nonresident recreation and tourism visitors make up over 5% of all jobs in rural counties in this region. That is nearly twice the national percentage, and three times the proportion for the South. Over 3% of income comes from serving these visitors, also more than twice the national average and over 4 times the proportion found in the South.

Relative Importance of Resource-Based Tourism

There were 472 rural counties (about 21% of the total) wherein over 6% (double the national average) of the total number of jobs were due to nonresident recreation visitation. In 372 counties (about 16% of the total) the percentage of income due to nonresident recreation visitation was at least 3% of the total income, or at least double the national average. In total, 338 counties had more than double the national percentage for both jobs and income. These are the counties that we define as most dependent on tourism. The majority of these dependent counties are located in mountainous portions of the West. Other concentrations occur in coastal areas, and near Forest Service, National Park Service, or other large public land holdings in the eastern half of the country.

Our estimates reflect only the jobs and income directly related to nonresident tourism visitation in the sectors most closely tied to that activity. Visitors may also affect other types of businesses, such as gas stations, travel agents, real estate services, and grocery stores. In addition, some other businesses are indirectly linked to recreation by supporting those businesses directly tied to recreation. Examples could include laundry or cleaning services for hotels or restaurants, insurance services, or wholesale suppliers. Some of these jobs could also be partly due to recreation visitors. As a result, the figures presented here may be a slightly conservative estimate of the economic effects of recreation in rural counties in the United States.

Characteristics of Counties Dependent on Resource-Based Tourism

Income

Counties dependent on tourism had significantly higher per capita income levels in 1990 than did nondependent counties (Table 3). Dependent counties also showed greater percentage increases in per capita income between 1980 and 1990 than did nondependent counties. However, the average household income in tourism dependent counties was not significantly greater than in nondependent counties. Despite differences in income level and growth, there was no difference in the proportion of

TABLE 3 Jobs and Income Attributable to Resource-Based Tourism, by Region and Sector

Sector	North	South	West	U.S. total
Eating/drinking				
Jobs (1000s)	126	78	96	300
Income (million $)	1333	981	1041	3455
Accommodations				
Jobs (1000s)	61	24	86	171
Income (million $)	1098	484	1896	3478
Retail trade				
Jobs (1000s)	65	53	53	171
Income (million $)	944	781	641	2366
Recreation services				
Jobs (1000s)	51	23	51	125
Income (million $)	833	404	1274	2511
Total				
Jobs (1000s)	303	178	286	767
Income (million $)	4208	2650	4952	11810
Importance of resource-based tourism[a]				
Jobs (in percent)	3.0%	1.8%	5.4%	3.1%
Income (in percent)	1.3%	0.8%	3.0%	1.5%

[a] This is simply the proportion of all jobs and income (from all sectors) that is attributable to resource-based tourism (from the three identified sectors) in selected nonmetropolitan counties.

the population that live in poverty. Other studies have uncovered empirical evidence identifying inequities and distributional issues tied to tourism development (Smith 1986; Leatherman and Marcouiller 1996b). Although inconclusive, our results do not indicate statistical differences between tourism-dependent and other rural counties with respect to income distribution as measured by Gini coefficients. Further work is required to more closely examine potential equity disparities in counties with significant tourism development.

Economic Structure

In general, the economic structure in tourism dependent rural counties was less diverse than in nondependent rural counties (Table 4). This indicates that tourism-dependent rural counties have less activity in manufacturing and production sectors, and a higher concentration in services and related sectors. In particular, there was significantly less economic activity in both the forestry and wood products manufacturing sectors in dependent counties. However, this pattern may be changing. From 1980 to 1990, dependent counties had a greater proportional increase in economic diversity than did nondependent counties.

Housing

Housing in tourism-dependent areas was more expensive than in other rural areas. The average house value was nearly $13,000 higher in 1990 in tourism-

TABLE 4 Regression Results (Unstandardized Regression Coefficients, *t*-Values in Parentheses) for Models Comparing Recreation and Other Rural Counties on Income-Related Dependent Variables

Independent variable	1990 Per capita income	1990 Average household income	Gini coefficient	1990 Percent poor	Percent PCI change, 1980–1990
Constant	10,366	26,826	.4021	15.44	3.80
	(134.90)	(142.21)	(365.9)	(50.03)	(7.55)
Recreation dependent	477.74	480.16	.0019	−0.260	2.43
	(4.56)	(1.87)	(1.25)	(−0.61)	(3.53)
West	−102.02	−3.19	.0006	1.03	−2.05
	(−1.05)	(−0.01)	(0.46)	(2.64)	(−3.20)
South	−1153.47	−2418.40	.0342	8.00	2.15
	(−13.47)	(−11.51)	(28.16)	(23.26)	(3.83)
Metro adjacent	691.41	2375.80	−.0101	−2.75	2.46
	(9.25)	(12.97)	(−9.39)	(−9.15)	(5.03)
Model *F*	81.67	79.50	268.31	176.15	22.99
R^2	.13	.12	.32	.24	.04

Note. PCI, per capita income.

dependent rural counties, compared to nondependent counties (Table 5). Proximity to metropolitan areas accounted for a difference in house value of about $8700. As could be expected, the proportion of housing units that were seasonally vacant was much higher (12.6%) in dependent counties. The proportion that were rented was nearly 4% lower compared to nonmetropolitan counties that were not dependent.

TABLE 5 Regression Results (Unstandardized Regression Coefficients, *t*-Values in Parentheses) for Models Comparing Recreation and Other Rural Counties on Housing-Related Dependent Variables

Independent variable	1990 Mean value	1990 Percent seasonally vacant	Percent change in value, 1980–1990	1990 Percent rented	Change in units, 1980–1990
Constant	46,005	16.16	−15.67	21.23	1006.8
	(45.41)	(36.25)	(−19.70)	(50.03)	(176.68)
Recreation dependent	12,797	12.63	7.43	−3.67	58.8
	(9.25)	(20.76)	(6.84)	(−9.91)	(3.53)
West	271.7	0.15	−8.01	3.05	4.6
	(0.21)	(0.27)	(−7.92)	(8.84)	(0.52)
South	−2604	−0.64	8.43	0.35	47.1
	(−2.37)	(−1.28)	(9.51)	(1.17)	(7.41)
Metro adjacent	8672	−2.04	6.20	0.07	59.4
	(8.80)	(−4.71)	(8.00)	(0.27)	(10.72)
Model *F*	41.62	136.68	108.51	39.07	57.53
R^2	.07	.20	.16	.06	.09

TABLE 6 Regression Results (Unstandardized Regression Coefficients, t-Values in Parentheses) for Models Comparing Recreation and Other Rural Counties on Economic Structure-Dependent Variables

Independent variable	1990 Diversity index	1990 Forestry value added	1990 Wood products value added	Percent diversity index change, 1982–1992
Constant	0.6053	392.1	4833.7	115.81
	(290.91)	(1.73)	(7.97)	(208.39)
Recreation	−0.0127	−781.2	−3433.7	2.07
dependent	(−4.47)	(−2.54)	(−4.14)	(2.73)
West	−0.0352	1972.3	1027.5	5.40
	(−13.33)	(6.84)	(1.33)	(7.67)
South	−0.0353	736.2	−670.0	2.40
	(−15.23)	(2.92)	(−0.99)	(3.86)
Metro	0.0133	219.33	1787.7	−0.45
adjacent	(6.57)	(3.18)	(3.03)	(−0.82)
Model F	94.35	13.47	7.16	20.75
R^2	.14	.02	.02	.04

From 1980 to 1990, tourism-dependent counties had higher growth in number of housing units and in the percentage increase in average housing value. That is, in these counties both the quantity and price of housing increased faster than in counties that are not so dependent on recreation.

Population

Our results confirm the findings of Beale and Johnson (1998) regarding population growth. The counties we defined as dependent on tourism are growing faster than other rural counties. From 1980 to 1990, after accounting for regional differences and proximity to metropolitan areas, population in recreation dependent counties grew about 5.36% more than did other rural counties (Table 6). From 1990 to 1995, these counties' population grew another 3.81% faster, compared to nondependent rural counties (Table 7). The populace in the recreation/tourism dependent counties tends to be better educated, and less tied to farming than in other rural counties. Nearly 1.5% more of the population members in the dependent counties have college degrees, and almost 3% fewer live on farms.

Discussion

Dependence on recreation and tourism in rural areas is clearly tied to proximity to certain types of natural resources, including beaches, large lakes, forests, and mountainous terrain. In areas where these resources are owned by public agencies, recreation and tourism seem to be especially important parts of the rural economy. Because of the link between public recreation resources and local economic structure, our results would seem to affirm the prominence that public land-managing agencies place on the local economic consequences of their policy decisions.

Resource-based tourism-dependent rural counties are experiencing greater increases in population growth and housing construction than are other rural

TABLE 7 Regression Results (Unstandardized Regression Coefficients, t-Values in Parentheses) for Models Comparing Recreation and Other Rural Counties on Selected Population-Dependent Variables

Independent variable	Percent increase in total population		1990 Percent college educated	1990 Percent female-headed households	1990 Percent living on farms
	1980–1990	1990–1995			
Constant	−5.352	1.101	7.490	10.44	10.063
	(−9.40)	(330.76)	(55.92)	(48.66)	(30.92)
Recreation	5.355	3.813	1.442	−0.180	−2.846
dependent	(6.90)	(9.14)	(7.89)	(−0.62)	(−6.41)
West	1.674	1.817	2.480	−1.379	3.260
	(2.31)	(4.68)	(14.57)	(−4.18)	(7.89)
South	3.822	1.698	−0.916	4.686	−3.856
	(6.03)	(4.99)	(−6.14)	(19.60)	(−10.63)
Metro	6.356	2.900	−0.071	0.261	−1.618
adjacent	(11.48)	(9.77)	(−0.55)	(1.25)	(−5.11)
Model F	51.18	48.12	170.24	177.15	103.53
R^2	.08	.08	.23	.24	.15

counties. Higher housing prices may reflect greater housing demand or more valuable private land close to recreation infrastructure. Such findings lend some support to observations made by Howe et al. (1997) that Americans are moving to rural areas for natural resource amenities and improved quality of life.

In-migration can lead to pivotal changes in the social structure and patterns in rural areas and communities, particularly if migrants are noticeably different from residents. Differences in education level, income level, regional background, and age structure may be among the salient characteristics of demographic structure in rural amenity-rich communities. We echo the concerns voiced by Beale and Johnson (1998) that new residents may demand different levels of social and community services, altering traditional patterns of local government spending. Although some evidence suggests that recreational homeowners are positive net contributors to local fiscal conditions (Deller et al. 1997), more work is needed to assess the effect of aging among in-migrating residents on locally available public services. Recent studies (Green et al. 1996) suggest that it also seems likely that such migrants would hold different values for the natural resource base and development options than do long-time residents, particularly in the desired mix of amenity and commodity outputs.

Our findings do not seem to support contentions that recreation and tourism jobs are necessarily lower with respect to aggregate local income generation, since mean incomes were higher in the more recreation-dependent counties. However, other phenomena may cloud the issue. For example, it is possible that mean incomes could be influenced by amenity-seeking migrants who bring with them higher incomes. That might explain why average incomes are higher in dependent counties, but the percent of population in poverty is not different from nondependent counties. Further research is needed to track changes in the tourism-sensitive sectors in the more dependent counties and control for the effect of migration, to examine how workers in those businesses are faring. In addition, research can concurrently track changes in income distribution in the dependent counties and can compare these to analogous changes in nondependent counties.

Clearly, identification of tourism-dependence counties depends on the methods used. Our choices in defining regions, clustering variables, and tourism resource variables were driven by a combination of administrative needs, previous research, and our own intuition. Further research is needed to develop guidelines for these types of decisions and to tie such guidelines to existing theoretical and conceptual models. For example, most research has noted that part of the difficulty in establishing the level of dependence on tourism is that the sectors affected by tourists are also affected by local residents and by visitors on nonrecreation trips. Our work has focused on highlighting one means to separate export employment that serves recreation and tourism visitation from export employment that serves visitors who come for other reasons. Future research is needed to examine the effect of assumptions inherent in our methods. For example, although we examined each of the four sectors independently, the nature of demand for these types of service may indicate the need for simultaneous equations. In addition, alternatives to minimum requirements could lead to different results on the overall level of export employment in tourism-related sectors.

Methods used by other researchers have led to a different set of counties being identified as tourism dependent. Beale and Johnson (1998) identified 285 nonmetropolitan recreational counties. We identified 338 such counties. Although the classification procedures and the thresholds for dependency differ between the two methods, there are 156 counties that both methods define as tourism dependent. According to our estimates, about 10% of all income and about 15% of jobs in these counties are due to nonresident tourism activity. Selection of those 156 counties is robust to divergent methods, so it seems that those counties might well be the ones most dependent on recreation and tourism. Other rural counties that have been classified by only one method or the other might represent a second and somewhat lower tier of tourism dependency.

An economy's dependence on recreation and tourism is difficult to characterize, due to how that "industry" affects the local economy. Further research is needed on how to identify and address the relation between tourism activity and the economic or social structure in rural counties. Separating activity that serves local versus export demand is a critical component targeted here. Migration and housing demand is another, as shown by Beale and Johnson (1998). Because projections for outdoor recreation and tourism show increases for most activities, such research may well play a vital part in forming public land management and local development policies. Further, as demands for tourism-related uses of natural resources increase, there will be trade-offs with commodity production. Thus, it will be important to coordinate research on commodity dependencies with tourism dependency, to accurately evaluate the effects of various options that face rural areas in the United States.

Notes

1. Pratt (1968) has criticized the minimum requirements approach on its assumption that each region within the peer set, except for the minimum peer, produces for export. In this critique, Pratt was looking at manufacturing sectors. Tourism, however, is a unique case of the export base concept. Nonresident visitors that provide tourism demands can be considered as purely basic. Unlike manufacturing sectors, tourism has no contrasting "import" demands. Tourism represents a purely export-driven activity. Thus the minimum requirements approach is conceptually a more valid approach to apply to tourism-sensitive sectors. In our case, we assume that all counties within a peer group have some level of tourism activity (except the minimum peer, which is assumed to have no export tourism demand) and that the minimum peer represents the basis for assessment. We further extend this to account for local population to control for nonrecreational tourism demands.
2. Factor score tables and tabular results from cluster analyses are available upon request from the primary author.

References

Beale, C. L., and K. M. Johnson. 1998. The identification of recreational counties in nonmetropolitan areas of the United States. *Population Res. Policy Rev.* 17:37–53.

Bender, L. D., B. L. Green, T. F. Hady, J. A. Kuehn, M. K. Nelson, L. B. Perkinson, and P. J. Ross. 1985. *The diverse social and economic structure of nonmetropolitan America.* Washington, DC: USDA–Economic Research Service, Report RDRR-49.

Brown, T. L. and N. A. Connelly. 1986. Tourism and employment in the Adirondack Park. *Ann. of Tourism Res.* 13(3):481–489.

Dawson, S. A., D. J. Blahna, and J. E. Keith. 1993. Expected and actual regional economic impacts of Great Basin National Park. *J. Park Recreation Admin.* 11:45–59.

Deller, S. C., D. W. Marcouiller, and G. P. Green. 1997. Recreational housing and local government finance. *Ann. of Tourism Res.* 24(3):687–705.

Duffy-Deno, K. 1998. The effect of federal wilderness on county growth in the intermountain western United States. *J. Regional Sci.* 38:109–136.

Dwyer, L., and P. Forsyth. 1997. Impacts and benefits of MICE tourism: A framework for analysis. *Tourism Econ.* 3(1):21–38.

English, D. B. K., and J. C. Bergstrom. 1994. The conceptual links between recreation site development and regional economic impacts. *J. Regional Sci.* 34:599–611.

Green, G. P., D. W. Marcouiller, S. C. Deller, D. K. Erkkila, and N. R. Sumathi. 1996. Local dependency, land use attitudes, and economic development: Comparisons between seasonal and permanent residents. *Rural Sociol.* 61(3):427–445.

Hady, T. H., and P. J. Ross. 1990. *An update: The diverse social and economic structure of nonmetropolitan America.* Washington, DC: Agriculture and Rural Economy Division, USDA–Economic Research Service, Staff Report AGES 9036.

Howe, J., E. McMahon, and L. Propst. 1997. *Balancing nature and commerce in gateway communities.* Washington, DC: Island Press.

Isserman, A. 1980. Estimating export activity in a regional economy: A theoretical and empirical analysis of alternative methods. *International Regional Science Review.* 5:655–667.

Johnson, K. M., and C. L. Beale. 1994. The recent revival of widespread population growth in nonmetropolitan areas of the United States. *Rural Sociol.* 59:655–667.

Johnson, P., and B. Thomas. 1990. Employment in tourism: A review. *Ind. Relations J.* 21:36–48.

Johnson, R. L., and E. Moore. 1993. Tourism impact estimation. *Ann. Tourism Res.* 20:279–288.

Kusmin, L., J. M. Redman, and D. W. Sears. 1996. *Factors associated with rural economic growth.* Washington, DC: USDA Economic Research Service, Tech. Bull. 1850.

Leatherman, J. C. and D. W. Marcouiller. 1996a. Estimating tourism's share of local income from secondary data sources. *Rev. Regional Stud.* 26:317–341.

Leatherman, J. C. and D. W. Marcouiller. 1996b. Income distribution characteristics of rural economic sectors: Implications on local development policy. *Growth and Change* 27(4):434–459.

Leiper, N. 1979. The framework of tourism: Toward a definition of tourism, tourist, and the tourist industry. *Ann. Tourism Res.* 6(4):398.

Leiper, N. 1990. Partial industrialization of tourism systems. *Ann. Tourism Res.* 17(4):600–605.

Nord, M., and J. B. Cromartie. 1997. Migration: The increasing importance of rural natural amenities. *Choices* 3:22–23.

Pratt, R. 1968. An appraisal of the minimum requirements technique. *Econ. Geogr.* 44:177–224.

Ross, P. J., and B. L. Green. 1985. *Procedures for developing a policy-oriented classification of nonmetropolitan counties.* Washington, DC: USDA Economic Research Service, Staff Report AGES850308, August.

Rothman, H. K. 1998. *Devil's bargains: Tourism in the twentieth century American West.* Lawrence: University Press of Kansas.

Smith, M. 1986. *Behind the glitter: The impact of tourism on rural women in the Southeast.* Lexington, KY: Southeast Women's Employment Coalition.

Smith, S. L. J. 1987. Defining tourism: A supply-side view. *Ann. Tourism Res.* 14(1):179–190.

Stynes, D. J., and G. L. Peterson. 1984. A review of logit models with implications for modeling recreation choice. *J. Leisure Res.* 16:295–310.

USDA–Forest Service. 1995. *The Forest Service Program for Forest and Rangeland Resources: A long-term strategic plan.* Draft 1995 RPA Program. Washington, DC.

USDA–Forest Service. 1997. *National Outdoor Recreation Supply Information System (NORSIS).* Resource data set compiled by USDA–Forest Service, Recreation, Wilderness, and Urban/Wildland Research Unit (SRS-4901), Athens, GA.

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Wednesday, March 25, 2015 11:36 AM
To: Walter, Hanspeter
Subject: Fwd: Coldwell Banker Revenues from Lake Fishing

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Susan Bryner** <susan.bryner@gmail.com>
Date: Wed, Mar 25, 2015 at 10:57 AM
Subject: Coldwell Banker Revenues from Lake Fishing
To: Sherrie Thrall <sherrie.thrall@gmail.com>

Hello Sherrie,

Sorry for late reply. I was out of town. Talked to Wendy and decided to pull similar numbers for our Vacation Rental Revenues related to fishing on our lake, 80% during shoulder season and 20% during season.

Given that, the potential loss of Vacation Rental revenue from our homes, should the lake be "un-fishable" would be between $95,000 and $125,000 annually.

Hope this helps!

Susan Bryner
BRE#01751530

Coldwell Banker Kehr/O'Brien
Real Estate & Property Management

499 Peninsula Drive,
Lake Almanor, CA 96137
530-596-3266 Real Estate Office
530-596-4386 Property Management
530-588-3799 Cell

www.SellingPlumasCounty.com
www.LakeAlmanorVacation.info

Economic Impacts of Recreational Spending on Rural Areas: A Case Study

John C. Bergstrom
University of Georgia

H. Ken Cordell
Gregory A. Ashley
Alan E. Watson
USDA Forest Service

Researchers, planners, and policymakers are becoming increasingly interested in the rural economic development potentials of outdoor recreation. Empirical evidence evaluating this economic development potential, however, is almost nonexistent. In this article, results of a study that examined local economic effects of spending associated with outdoor recreation in selected rural areas are reported. Recreational expenditures were collected as part of the Public Area Recreation Visitors Study (PARVS). Economic impacts of these expenditures were estimated using regional input-output models developed from the USDA Forest Service input-output model and data base system (IMPLAN). Results indicated that recreational spending contributed substantially to gross output, income, employment, and value added in the studied rural areas. These results suggest that outdoor recreation may be a viable rural economic development strategy.

John C. Bergstrom is Assistant Professor in the Department of Agricultural Economics, University of Georgia, Athens.

H. Ken Cordell is a Project Leader with the Southeastern Forest Experiment Station, USDA Forest Service, Athens, Georgia.

Gregory A. Ashley is an Outdoor Recreation Planner with the Southeastern Forest Experiment Station, USDA Forest Service, Athens, Georgia.

Alan E. Watson is a Research Social Scientist with the Intermountain Forest and Range Experiment Station, USDA Forest Service, Missoula, Montana.

Severe poverty and unemployment persists in many rural areas, particularly in the South. Federal, state, and local governments are increasingly interested in economic improvement programs for these rural areas.[1] The purpose of this article is to present the results of a study that examined local economic development effects of recreational spending on selected rural areas. The economic development potential of outdoor recreation has been almost completely ignored in the literature. Results reported in this article suggest that recreational spending stimulates a considerable amount of economic activity in rural economies. Hence, outdoor recreation may provide a viable development strategy for some rural communities.

Methodology for measuring the economic impacts of recreational spending on rural areas is discussed in the following section. The study used data from the Public Area Recreation Visitors

AUTHORS' NOTE: This research was supported by USDA Forest Service Cooperative Research Agreement Supplement No. 121 to contract No. 12-11-008-876, the Georgia Agricultural Experiment Station under the W-133 Regional Project, and the Georgia Department of Natural Resources (DNR). Data collection efforts coordinated by Terri Yearwood and Steve Tribble of the Georgia DNR are gratefully acknowledged. We would also like to acknowledge the joint work of the Public Area Recreation Visitors Study in development of the database upon which the economic analysis is based. Special contributions were made by Dr. Alan Watson (survey design and data set configuration); Dr. Larry Hartman (questionnaire design and field operations); Dean Klein, Stacey Meadows, and Carter Betz (field survey and data management); Eric Siverts, Dr. Greg Alward, and Dr. Dennis Propst (IMPLAN interface); Eric Siverts, Richard Greenhaugh, and Don English (IMPLAN operation); and Gary McGlamory, Mark Cowell, Merritt Clifton, and Neal Tam (data compilation and table construction). Appreciation is also expressed to four anonymous reviewers for helpful comments and suggestions.

ECONOMIC DEVELOPMENT QUARTERLY, Vol. 4 No. 1, February 1990 29-39

Study (PARVS) and an input-output modeling system developed by the U.S. Forest Service (IMPLAN). After the methodology discussion, empirical results are presented and discussed. A summary, policy implications, and conclusions are offered in the final section.

METHODOLOGY

Background Concepts

The economic effects of outdoor recreation spending on rural areas may be measured in terms of direct, indirect, and induced effects. Recreation is a basic exporting industry as defined in standard export base theory. The "exports" of a park, for instance, are recreational services provided to people who live outside of the local area near the park, usually viewed as the surrounding counties. Exports of recreational services bring outside dollars into an economy and stimulate economic activity. The process by which this economic activity leads to growth is perhaps best explained through a simplified, hypothetical example.

Assume a rural area has a number of petroleum-related firms (e.g., service stations, wholesale gasoline distributors), as well as a state park. Nonresident visitors to the park spend money on a variety of items. Major expenditure categories include transportation, lodging, food and beverages, fees, and miscellaneous supplies. While visiting the park, for example, visitors may purchase gasoline for automobiles, recreational vehicles, and boats at local service stations. In order to meet the increased demand for gasoline, local service stations must increase purchases of gasoline and other products from other industries. These first-round purchases are the inputs for the local service stations and represent the *direct effects* of recreational spending on the local rural economy.

In order to increase sales of inputs to service stations, input suppliers must in turn increase their purchases of inputs from other industries. For example, gasoline wholesalers must increase purchases of gasoline from oil refineries. These purchases would result in even more economic activity, because, in order to meet increased input demand from gasoline wholesalers, input suppliers (e.g., oil refineries) would also have to purchase more inputs. Thus the increase in input purchases made by service stations in order to meet increased demand for gasoline from park visitors initiates a "chain reaction" of additional purchases in the local rural economy. The economic activity stimulated by these multiple-round input purchases are the *indirect effects* of recreational spending on the rural area economy.

The direct and indirect effects of recreational spending result in an overall increase in the production and distribution of goods and services in a rural area. This increase in economic activity results in increased employment and household income. Increases in household income, in turn, increase consumer demand for goods and services. For example, as a result of increased demand for gasoline caused by park visitors, local service stations may hire additional employees and/or increase employee wages. Given additional income, the service station employees will increase purchases of consumer goods such as clothes, food, and gasoline for their automobiles. In order to meet this increased demand, even more multiple-round purchases of inputs will be stimulated. Economic activity stimulated by increased consumer purchases are the *induced effects* of recreational spending on the rural area economy.

The total economic effects of outdoor recreation on a rural area are measured by the sum of direct, indirect, and induced effects of recreational spending. The direct and indirect effects account for the first and subsequent rounds of input purchases made in order to support firms that directly provide recreational visitors with goods and services. The induced effects account for increased input purchases made in order to meet increased demand for goods and services caused by increased household income in the local rural economy. The direct, indirect, and induced effects of recreational spending are referred to as secondary economic benefits.[2]

Secondary economic benefits do not necessarily increase economic efficiency or contribute to national economic development. Gains caused by increased recreational spending in one region may be offset by losses in another region. This assumption however, is usually valid only if the economy is at full employment, and it usually is not. Also, people within a region who never used state parks may be enticed to do so by their proximity to a park or improvement of recreational services offered. Secondary economic benefits, however, do contribute to regional economic

TABLE 1
Representative Georgia State Parks and Adjacent Counties Forming the Local Impact Regions

State Park	*Adjacent Local Counties*
Unicoi	White
	Lumpkin
	Hall
	Banks
	Habersham
	Towns
	Union
Red Top	Bartow
	Gordon
	Pickens
	Cherokee
	Paulding
	Polk
	Floyd
F. D. Roosevelt	Harris
	Troup
	Meriwether
	Talbot
	Chattahoochee
Little Ocmulgee	Tel Fair
	Wheller
	Jeff Davis
	Coffee
	Ben Hill
	Wilcox
	Dodge
Dahlonega Gold Museum	Lumpkin
	White
	Hall
	Dawson
	Fannin
	Union

development and may meet welfare distributional objectives related to redistribution of income and employment to economically depressed rural areas.[3]

Data Collection

The secondary benefits of outdoor recreation were empirically estimated for five representative state parks in Georgia. These parks, selected with the assistance of the Georgia Department of Natural Resources, were Unicoi State Park, Red Top State Park, Dahlonega Gold Museum State Park, F. D. Roosevelt State Park, and Little Ocmulgee State Park. Unicoi, Red Top, and Dahlonega Gold Museum State Parks are located in the north Georgia mountain region. F. D. Roosevelt State Park is located in the central Georgia Piedmont region, and Little Ocmulgee State Park is located in the south Georgia coastal plain region. All parks are located in predominantly rural areas. For each park, a local impact region was defined as the county where the park is located, plus all counties contiguous to that county. Counties included in these local regions are listed in Table 1.

Estimation of the economic effects of state parks requires data on park visitors' spending in the local region. Visitor expenditure data were collected as part of the Public Area Recreation Visitor Study (PARVS). PARVS is a nationwide cooperative effort to collect data on the economic benefits of outdoor recreation and tourism. Six federal agencies, 16 states, four national associations, and six universities have cooperated to implement PARVS. Since 1985, continuing data collection efforts have resulted in about 52,000 interviews at about 320 sites across the country.[4]

. . . the Public Area Recreation Visitor Study . . . is a nationwide cooperative effort to collect data on the economic benefits of outdoor recreation and tourism. Six federal agencies, 16 states, four national associations, and six universities have cooperated to implement PARVS.

Survey Procedures

At the five study parks in Georgia, PARVS enumerators conducted on-site interviews of visitors as they exited the park. Interviews were coordinated by the Georgia Department of Natural Resources. Data were collected on travel patterns, on-site activity, participation and participant characteristics, and recreation patterns throughout the year. Interviewed visitors were also asked to provide their names, addresses, and phone numbers for a follow-up mail survey. From this list of names and addresses, the sample of visitors was sent a survey questionnaire through the mail.

The mail survey questionnaire asked respondents detailed questions on equipment usage, year-long recreation-related spending, and expenditures related to their trip to the Georgia state parks. Respondents were asked first to report trip-related expenditures made at their residence, either before the trip (e.g., purchase of film) and after the trip (e.g., payment for developing exposed film). Respondents were then asked to report expenditures made while en route from their residence to the park (e.g., gasoline and food purchases). Next, respondents were asked to report expenditures made while at the park before leaving to return home or to travel on to other sites (e.g., food and lodging, souvenirs, fees, ice). Finally, respondents were asked to report annual expenditures made on outdoor recreation in general (e.g., purchase or repairs of recreational equipment).

Pilot testing of sampling procedures for on-site interviews and for the mail survey follow-ups, within the constraints of a limited budget, led to adoption of selective sampling of exiting park visitors at intervals dictated by the time required to complete the rather lengthy PARVS survey form. Because of this length, interview numbers were maximized using a strategy of intercepting the next available exiting park user after an interview had been completed. This strategy was used throughout the daily interview period. The number of exiting vehicles was recorded while each interview was in progress, and the ratio of recreational and nonrecreational vehicles encountered through interview contacts were maintained. These data, plus existing visitor count records from the state parks, were used to postsample weight interview records to account for disproportionate sampling among park user strata, especially day versus overnight visitors.

Follow-up mail questionnaires were sent to each on-site interviewee. The equipment usage and year-long and trip expenditure data gained from the mail survey was central to this economic study. For this reason, special care was taken in postsample weighting of each mail follow-up respondent's record because the on-site selective samples were further diluted by mail survey response rates of less than 100%. This weighting emphasized four strata; day versus overnight developed-site users and day versus overnight dispersed-area users. Such weighting, of course, only partially corrected for possible sample bias, that is, that potentially caused by disproportionate representation among strata. Possible representation of a population's expenditures within a strata could not be corrected by post sample weighting given the limited preexisting data describing user's characteristics.

Relatively low response rates to the mail follow-up survey further contributed to the resulting low numbers of cases. Given the relatively small number of cases per study park (Table 2), sample numbers were increased by pooling interview records obtained at the other Georgia state parks on which PARVS was implemented. Pooling occurred only across parks of similar purposes facilities and attractions, for example, historic parks. These pooled data increased sample sizes sufficiently to engender statistical stability in the expenditure data. The authors acknowledge, however, that larger sample sizes, which included only cases explicit to the studied representative parks, would likely have provided a superior data set. Within these data constraints, however, the objective of this study is still well served for several reasons. The expenditure data used reflect actual recreational spending; mean expenditures were weighted to reproportion samples among represented strata; and comparisons with expenditure means from similar state and federal areas showed highly comparable results.

IMPLAN Analysis

The expenditure items included in the PARVS mail survey questionnaire were developed specifically to provide visitor expenditure profiles compatible with IMPLAN, a computer-based input-output data base and model developed by the Land Management Planning Division of the USDA Forest Service. The IMPLAN software system consists of (1) an input-output data base,

TABLE 2
Recreation Trip Expenditure Profiles for Samples of Visitors to Representative Georgia State Parks

	Mean Expenditures Per Person Per Trip (1986 dollars)				
Category	*Unicoi*	*Red Top*	*F.D. Roosevelt*	*Dahlonega Gold Museum*	*Little Ocmulgee*
Transportation	$ 6.18	$0.49	$ 1.91	$ 1.01	$13.26
Food and Beverages	16.38	6.07	11.82	9.96	25.69
Lodging	6.81	0.73	4.20	0.00	4.07
Activities	0.59	0.09	0.56	0.07	1.05
Miscellaneous	2.46	0.04	0.28	1.29	1.49
Total	32.42	7.42	18.77	12.33	45.58
Number of Observations	52	34	23	29	20

(2) several program modules for constructing interindustry models for the user designated impact region, and (3) a model that calculates the direct, indirect, and induced effects of changes in final demand.[5] The IMPLAN input-output data is composed of a national-level technology matrix and county-level estimates of final demand, final payments, gross output, and employment for economic sectors. The national technology matrix denotes fixed coefficient production functions for economic sectors. The matrix was derived from the 1972 national input-output model updated to 1982.

The county-level estimates of final demand, final payments, gross output, and employment were derived from a number of secondary sources. These sources included the U.S. Department of Commerce, County Business Patterns, Dunn and Bradstreet Corporation employment data, and various censuses conducted by the U.S. Department of Commerce (e.g., Agriculture, Manufacturing, and Population and Housing). All data were adjusted to the IMPLAN base year of 1982.[6]

Input-output accounts for a region are developed within the IMPLAN system using nonsurvey techniques. In particular, regional accounts are derived by a "downward movement" approach by which national input-output data are disaggregated to state and county levels. The county-level estimates of final demand, final payments, gross output, and employment serve as "control totals" at the state and local levels. The national technology matrix is then applied to derive interindustry purchases (inputs) and sales (outputs) for a region. The end result of this process is a complete, nonsurvey based input-output account for a region.[7]

IMPLAN is subject to commonly recognized limitations of national, nonsurvey-based input-output models. The general concern is whether such highly aggregated nonsurvey techniques generate accurate "pictures" of a local economy. First, secondary data sources used to derive county-level estimates of final demand, final payments, gross output, and employment may be incomplete, inconsistent, and inaccurate.[8] It is therefore advisable, when feasible, to compare county-level estimates of final demand, final payments, gross output, and employment provided in IMPLAN with other local data bases such as state government labor statistics.[9] In addition, all data in IMPLAN are adjusted to 1982. Economic activity in a region may change considerably over time, especially in rural areas experiencing rapid expansion or contraction. Thus there is a need periodically to evaluate and update county-level estimates of final demand, gross output, and employment provided in IMPLAN.

Another major limitation of IMPLAN resulting from its nonsurvey-based framework is the application of national technical coefficients (or production functions) to every disaggregated region. This procedure ignores geographical differences in production processes, and production variations between firms in an industry.[10] If the user has more and/or better information on production processes for industries in a region (e.g., farming practices in a rural area), IMPLAN provides the capability for the user to adjust regional technical coefficients.[11] Even assuming that the national technical coefficients are appropriate for a region, production technology may change over time. Hence, it would be desirable periodically to evaluate and adjust the national technical coefficients, which are already over 10 years old.[12]

Another potential problem in the application of IMPLAN are changes in the structure of the regional economy. IMPLAN assumes that the industries within a regional economy remain stable over time. However, especially in certain, unstable rural areas, industries may both enter and leave the region over time. In a rural economy, the addition or subtraction of only one industry (e.g., manufacturer) may cause a major "shock" to the economy. Thus it may also be important periodically to evaluate and update the structure of county-level industries contained in IMPLAN.[13]

Despite its limitations, IMPLAN is widely applied and professionally accepted both within and outside the U.S. Forest Service. A recent cross-check of IMPLAN using more recent and detailed county-level control data indicated that impact results generated by IMPLAN appear reasonably accurate.[14] Thus, although caution should be exercised in applying IMPLAN, it appears to be a useful, valid, and powerful tool for economic impact analysis. IMPLAN is especially amenable to assessing the economic impacts of outdoor recreation.[15]

In this study, the IMPLAN modules were employed to construct regional input-output models for each of the local impact regions listed in Table 1. The models then were used to calculate the direct, indirect, and induced effects of recreational spending. Recreational expenditures and the input-output data describing the local impact regions (e.g., sales, population) were for the year 1986.

The first step in the economic impact estimation process was to determine the allocation of recreational expenditures among IMPLAN sectors. This allocation was made using an algorithm (or "bridge" table) developed by a number of cooperating PARVS researchers.[16] This allocation algorithm was based upon producer price and marketing margin data provided by the Bureau of Economic Analysis (BEA). For example, on visits to Georgia state parks, visitors may spend money on gasoline for automobiles, recreational vehicles, and boats. Using the BEA data, recreational spending on gasoline was allocated to the following IMPLAN sectors through increased input purchases: petroleum refining; lubricating oils and greases; petroleum and coal production; rail, motor freight, water, air, and pipe transportation; other wholesale trade; and other retail trade.

Once it was determined how recreational expenditures should be allocated across IMPLAN sectors, it was necessary to estimate the appropriate portion of total trip expenditures to allocate for economic impact analysis. This allocation was also based on procedures developed by cooperating PARVS researchers.[17] First, only expenditures made by visitors living outside of the local impact region were considered. The following assumptions were then made for allocating a portion of trip-related expenditures for each specific IMPLAN sector to a local impact region. Allocation procedures were performed for each local impact region separately.

As discussed previously, four basic categories of trip-related expenditures were collected. The first category was expenditures made at home, before or after the trip. Because these expenditures all occur outside the local impact region, they were not included in the economic impact analysis. The second category of expenditures was money spent on the trip to and from the park. Some of these expenditures (e.g., gasoline purchases) likely occurred within the local impact region. The probability that en route expenditures occurred within the local impact region was estimated by dividing the average radius of the local impact region by the total one-way miles traveled. For example, if a visitor traveled 100 one-way miles to a park and the local impact region had a radius of 25 miles, this probability would be equal to 0.25 = 25/100. The estimated probability weight was then multiplied by total en route expenditures to give the portion of en route expenditures which occurred in the local impact region. In the forgoing example, if the visitor spent a total of $40 en route to and from the park, $10 = 0.25 × $40 was allocated to the local impact region.

The third, and most important, expenditure category was spending at the park or in the immediate vicinity of the park. It is assumed that all of these expenditures were made within the local impact region. Hence, all expenditures reported in this category were allocated across the IMPLAN sectors.

The fourth expenditure category was annual purchases of recreational supplies, gear, and equipment (e.g., fishing gear). Purchases of these items for use at a Georgia state park made within the local impact region will also stimulate economic activity in the region. Only expenditures on equipment or other goods that the respondents had with them on the trip during which they were interviewed were considered. Annual expenditures were first multiplied by the ratio of days of use at the interview site to total days of use elsewhere. The resulting number was then divided by annual trips to the interview site. The result was an estimate of annual expenditures per trip. This portion was further reduced by multiplying it by the probability of the annual expenditures occurring within the local impact region. This probability was estimated and applied following similar procedures used for allocating a portion of en route expenditures to the local impact region.

After determining the portion of total trip expenditures to assign to the local impact region, mean expenditures per person per trip were calculated. Mean expenditures per person per trip were then multiplied by annual visitation estimates provided by the Georgia Department of Natural Resources to calculate annual recreational expenditures attributable to a particular park. These total expenditures were then allocated across the appropriately affected IMPLAN sectors. The economic impact module in IMPLAN was then run to estimate total gross output, personal and property income, total income, employment, and value added which result from recreational spending in the local impact region.

RESULTS

The overall response rate for the PARVS mail questionnaire designed to collect recreational trip-related expenditures was 22%. In all, 200 usable questionnaires were returned. The basic profiles of expenditures made within each local impact region are shown in Table 2. As indicated in the table, most expenditures are for transportation, lodging, and food.

The direct, indirect, and induced effects of recreational spending on local impact regions are summarized in Table 3. Total gross output measures the value of all outputs produced in a local impact region; thus, it is an overall indicator of economic activity analogous to the gross national product (GNP) for the United States. Employee compensation is wages and salaries paid to employees of firms and businesses located in the local region. Property income is profits, rents, royalties, interest, and related payments that accrue to owners of property, firms, and businesses located in the local region. Total income is the sum of the employee compensation and property income. Value added is the sum of employee compensation, indirect business taxes, and property income. Basically, value added accounts for the income accruing to a local impact region when an output is produced and sold. Employee compensation and property income are paid directly to region residents, and indirect business taxes indirectly benefit residents through their local government. Employment refers to numbers of people employed by firms and businesses located in the local impact region.[18]

The numbers in Table 3 indicate that recreational expenditures at state parks stimulate a proportionately large amount of economic activity in surrounding rural areas of Georgia. Annual visits to Unicoi State Park, for example, supported over 1,400 jobs and over $14 million of total income in the local region in 1986. For each economic indicator reported in Table 3, about 50% of the total effects of recreational spending, in general, is accounted for by direct effects. Induced effects generally account for the next largest portion of the total effects of recreational spending, followed by indirect effects. The fact that induced effects are proportionately important signifies that local workers benefit as do the local businesses with which they trade.

. . . recreational expenditures at state parks stimulate a proportionately large amount of economic activity in surrounding rural areas of Georgia. Annual visits to Unicoi State Park, for example, supported over 1,400 jobs and over $14 million of total income in the local region in 1986.

The economic effects of spending stimulated by state parks varies considerably across the five parks analyzed in this study. The greatest effects are associated with Unicoi State Park, the most heavily visited. Unicoi State Park is the largest of the five parks with numerous hiking trails, camping facilities, a recreational lake, tennis courts, and a state operated convention center. The park attracts a large number of both day and overnight visitors. The smallest economic effects are associated with F. D. Roosevelt, Little Ocmulgee, and Dahlonega Gold Museum state parks. These state parks are rather modest, attracting relatively small numbers of primarily day use visitors. Red Top State Park generates moderate economic effects. Attractions at Red Top State Park, which are perhaps more typical of state parks, include camping, hiking, swimming, and picnicking. Red Top State Park attracts a greater number of day and overnight users, as compared to F. D. Roosevelt, Little Ocmulgee, and Dahlonega Gold Museum state parks.

The rural economic development potential of outdoor recreation is summarized by the regional economic multipliers shown in Table 4. Regional multipliers show the total effects of recreational spending (direct, indirect, and induced effects) per unit of direct effect.[19] The employment multiplier for Red Top State Park, for example, is 1.5. This means that 1.5 jobs will be created in the local economy per each job created by the direct effects of recreation spending. Thus if 10 new jobs resulted from the direct effects of recreational spending, 15 total jobs would eventually be

TABLE 3
Economic Effects of Recreational Spending at Representative Georgia State Parks

	Economic Effects (millions of dollars)					
Source of Effect by Park	Total Gross Output	Employee Compensation	Property Income	Total Income	Value Added	Employment (actual number)
Unicoi State Park						
Direct Effects	$21.1937	$6.1129	$2.4287	$8.5416	$9.7100	$1185.19
Indirect Effects	4.3877	1.3261	0.5975	1.9236	2.0331	76.83
Induced Effects	7.5634	2.3087	1.5926	3.9013	4.4320	173.25
Total Effects	33.1448	9.7478	4.6187	14.3665	16.1752	1435.26
Red Top State Park						
Direct Effects	13.3089	4.1409	0.6600	4.8008	5.4711	414.75
Indirect Effects	2.7197	0.7536	0.4816	1.2352	1.3288	47.90
Induced Effects	7.7550	2.2108	1.7286	3.9395	4.4750	166.91
Total Effects	23.7835	7.1054	2.8702	9.9755	11.2749	629.56
F. D. Roosevelt State Park						
Direct Effects	1.4924	0.4414	0.1381	0.5795	0.6603	74.99
Indirect Effects	0.2381	0.0762	0.0341	0.1103	0.1170	4.70
Induced Effects	0.5278	0.1665	0.1163	0.2829	0.3221	12.68
Total Effects	2.2583	0.6841	2.2886	0.9727	1.0993	92.37
Dahlonega Gold Museum State Park						
Direct Effects	0.4881	0.1515	0.0507	0.2022	0.2268	23.18
Indirect Effects	0.0905	0.0257	0.0133	0.0390	0.0416	1.63
Induced Effects	0.1420	0.0431	0.0298	0.0729	0.0828	3.28
Total Effects	0.7206	0.2202	0.0939	0.3141	0.3512	28.09
Little Ocmulgee State Park						
Direct Effects	2.8517	0.8985	0.2781	1.1766	1.3415	199.00
Indirect Effects	0.5900	0.1518	0.0813	0.2331	0.2470	9.93
Induced Effects	2.1648	0.6486	0.4564	1.1049	1.2583	54.30
Total Effects	5.6065	1.6989	0.8158	2.5146	2.8468	263.23

added to the local region — 10 resulting from the direct effects of recreational spending and five more from the indirect and induced effects.

The larger the regional economic multiplier, the greater is the potential for recreational spending to stimulate increased economic activity in a rural area. As indicated in Table 4, recreational spending appears to be associated with relatively large multipliers. Hence, new or expanded outdoor recreational facilities and attractions may bring new dollars into a rural area, which, through multiplier effects, stimulate considerable economic growth. The magnitude of the multipliers estimated for Georgia is consistent with previous studies. A review of previous studies, for example, showed total gross output multipliers ranging from 1.46 to 2.60.[20]

LOCAL DEVELOPMENT POLICY IMPLICATIONS

Poverty and joblessness exist in many rural areas. Local governments in such rural areas are becoming increasingly interested in implementing economic development programs. In the past, local economic development efforts have focused on attempting to attract new manufacturing plants, factories, and related industrial development. New industrial development, however, may fail to meet local economic development expectations. A new industry, for instance, may import specialized employees and not employ large numbers of local workers, and multiplier effects may turn out to be smaller than anticipated. New industrial development may also create new problems for rural areas such as environmental pollution, strains on natural resources (e.g., water supplies), conflicts with established rural enterprises (e.g., farmers), and strains on local utilities.

The results of this study suggest that outdoor recreation may provide a viable economic development alternative for rural areas.

The results of this study suggest that outdoor recreation may provide a viable economic development alternative for rural areas. Recreation-related multipliers estimated for gross output,

TABLE 4
Local Economic Multipliers for Recreational Spending at Representative Georgia State Parks

Economic Indicator	*Local Multipliers*				
	Unicoi	*Red Top*	*F. D. Roosevelt*	*Dahlonega Gold Museum*	*Little Ocmulgee*
Total Gross Output	1.56	1.79	1.51	1.48	1.97
Employee Compensation	1.59	1.72	1.55	1.45	1.89
Property Income	1.90	4.35	1.66	1.85	2.93
Total Income	1.68	2.08	1.68	1.55	2.14
Value Added	1.67	2.06	1.66	1.55	2.12
Employment	1.21	1.52	1.23	1.21	1.32

employment, and income are relatively large, which suggests that the direct, indirect, and induced effects of recreational expenditures stimulate a considerable amount of economic activity in rural economies. In addition, outdoor recreation development, for example, park development, can be undertaken in such a way that natural resources are conserved and environmental quality improved. Outdoor recreation development may also be complementary with established rural enterprises such as agriculture.

Local leaders in rural areas can facilitate outdoor recreation development in several ways. First, suppose a rural area is already endowed with land or water resources open to the public for outdoor recreational use (e.g., national or state park, national or state forest, large private tracts, reservoirs, or rivers). Economic growth in a rural area results from local expenditures by visitors who live outside of the rural area where these resource opportunities exist. Thus local economic development can be facilitated by encouraging increased out-of-region visitation through promotion of local recreational opportunities, improving access to local recreational attractions, and by raising the level and quality of services and attractions. Advertising, for example, may consist of travel brochures, maps, and newspaper and magazine advertisements. Improved access, for example, may involve the construction of new roads and airport facilities. Local leaders may need actively to solicit funding for such projects from federal, state, and local sources. But more important, by doing the kind of analysis demonstrated in this study, the benefiting businesses and industries can be identified, contacted, and asked to contribute.

Local leaders may also be able to encourage and facilitate the development of new or additional outdoor recreational facilities in rural areas. There may be opportunities, for example, for local agencies to cost-share or enter into partnership arrangements with federal or state agencies on outdoor recreational facility development. It is also feasible for local agencies to develop and operate outdoor recreational facilities on their own. Developing facilities for people to visit unique local attractions (e.g., historical structure, natural scenic attractions) is a distinct opportunity for local agencies.

The results of this study suggest that some of the largest economic impacts are associated with highly developed outdoor recreational facilities (e.g., resort facilities). Such facilities are often developed and operated by private firms. Thus, using the same techniques for attracting industrial development, local agencies can attempt to attract private development of outdoor recreational and tourism facilities. Major resorts, however, are expensive and bring negative externalities to a rural area, including pollution, congestion, and increased strains on local public services and facilities.

Local agencies should carefully evaluate all proposals for outdoor recreational development, whether publicly or privately supported. The potential economic benefits of outdoor recreation development can be assessed using economic impact analysis techniques, such as described in this article. These benefits must be compared to the potential costs of outdoor recreational development. Out-of-pocket development and operation costs may be relatively straightforward to measure. Environmental and other costs caused by intensively developed outdoor recreational facilities (e.g., major resorts) are important to consider, but difficult to quantify. The opportunity costs of devoting local resources to outdoor recreational development, instead of some other form of economic development, are also important to consider, but difficult to quantify.

Local leaders should also carefully assess the local business infrastructure to determine whether the types and diversity of extant businesses and services can effectively support growth. Programs to attract and stimulate recreation-related or support industries can further increase multipliers and economic growth effects. Attracting more and higher quality recreation and tourism attractions along with stimulating business growth in the economic sectors affected by recreation are highly important tandem strategies for local economic growth.

SUMMARY AND CONCLUSIONS

Economic impact analysis measures economic growth stimulated by increases in final demand for products produced in a regional economy. In the case of outdoor recreation, recreational services are produced and "exported" from a region. An increase in demand for these recreational services, measured by an increase in visits or trips to the local area, results in increased recreational spending and increased economic growth.

In this article, the economic effects of recreational spending on selected rural areas in Georgia were estimated. Recreational expenditures associated with visits to state parks were estimated from data provided by the Public Area Recreation Visitor Study (PARVS). The direct, indirect, and induced effects of these expenditures on the local region surrounding a particular state park were estimated using IMPLAN. IMPLAN is an input-output modeling system developed by the USDA Forest Service. IMPLAN results indicated that recreational spending can stimulate a considerable amount of economic activity in rural areas.

The magnitude of economic activity stimulated depends on the attractiveness of parks to out-of-region visitors and on the structure and diversity of the local economy. Currently, many state parks in rural areas of Georgia and other states have not yet achieved major destination status for out-of-region visitors. Improved management, however, may be able to change this status.

The results suggest that for some rural areas, outdoor recreation will likely provide a viable economic development alternative. This potential viability is supported by the relatively large multipliers estimated for employment, income, and other economic indicators. In addition to creating new jobs and economic activity, outdoor recreation is generally compatible with existing rural enterprises such as tourism and agriculture, and helps to enhance the overall quality of life by providing recreational opportunities to local residents. Of course, new recreational development should not proceed if the total costs (e.g., tax expenditures, negative externalities) exceed the total benefits of development.

More focused research is needed on the economic impact of outdoor recreation on regional economies. Input-output analysis, although widely used and accepted, is limited by strict analytical assumptions and the structure of existing computer routines. It would be useful to compare the results reported in this article to those obtained using alternative economic impact analysis techniques, such as econometric models. Also, the sensitivity of results reported in this article to assumptions regarding the allocation of recreational expenditures to local impact regions and specific IMPLAN sectors is unknown.

Future research efforts should examine these assumptions, modifying them as needed to generate alternative economic impact results. Additional research is also needed to improve procedures for collecting expenditure data. Although limited, the combination of the PARVS data base and the IMPLAN model represents a credible system for estimating the economic impacts of outdoor recreational spending on regional economies. Thus the results reported in this article may provide useful inputs into resource management and rural development policy decisions.

NOTES

1. Lionel J. Beaulieu, ed., *The Rural South in Crisis Challenges for the Future* (Boulder, CO: Westview, 1988).
2. J. R. Stoll, J. B. Loomis, and J. C. Bergstrom, "A Framework for Identifying Economic Benefits and Beneficiaries

of Outdoor Recreation," *Policy Studies Review* 7 (1987): 443-452; R. G. Walsh, *Recreation Economic Decisions: Comparing Benefits and Costs* (State College, PA: Venture Publishing, 1986).

3. E. J. Mishan, *Cost-Benefit Analysis* (New York: Praeger, 1976); P. G. Sassone and W. A. Schaffer, *Cost-Benefit Analysis: A Handbook* (New York: Academic Press, 1978); Stoll et al., "Framework."

4. H. K. Cordell, L. A. Hartman, A. E. Watson, J. Fretschen, O. B. Propst, and E. L. Siverts, "The Background and Status of an Interagency Research Effort: The PARVS," in *1986 Southeastern Recreation Research Conference*, ed. B. M. Cordell (Athens: Recreation Technical Assistance Office, Institute of Community and Area Development, University of Georgia, 1987).

5. C. J. Palmer and E. L. Siverts, *IMPLAN Analysis Guide*, Land Management Planning Systems Section (USDA Forest Service, Fort Collins, CO, 1985).

6. G. S. Alward, "Extending the IMPLAN I/O System: The Social Accounting Matrix" (Paper delivered at the Midwest Forest Economist's Meeting, Iowa State University, Ames, IA, May 1985); G. S. Alward, H. G. Davis, K. A. Despotakis, and E. M. Lofting, "Regional Non-Survey Input-Output Analysis with IMPLAN" (Paper delivered at the Southern Regional Science Association Annual Meetings, Washington, DC, 1985); G. S. Alward and C. J. Palmer, "IMPLAN: An Input-Output Analysis System for Forest Service Planning," in *Proceedings of the First Forest Sector Models* (Williamsburg, VA: AB Academic Publishing Oxford 1981); Palmer and Siverts, *IMPLAN Analysis Guide*.

7. Alward and Palmer, "IMPLAN;" Alward et al., "Regional Non-Survey."

8. Alward et al., "Regional Non-Survey;" J. E. Hotvedt, R. L. Busby, and R. E. Jacob, "Use of IMPLAN for Regional Input-Output Studies" (Paper, delivered at the Southern Forest Economic Annual Meeting, Buena Vista, Florida, 1988).

9. Palmer and Siverts, *IMPLAN Analysis Guide*; Hotvedt et al., "Use of IMPLAN."

10. Alward et al., "Regional Non-Survey."

11. Ibid.; E. L. Siverts, "Analytical Opportunities Using IMPLAN" (Paper delivered at the Midwest Forest Economist's Meeting, Iowa State University, Ames, IA, May 1985.)

12. Siverts, "Analytical Opportunities."

13. Ibid.

14. Hotvedt et al., "Use of IMPLAN."

15. G. S. Alward and E. M. Lofting, "Opportunities for Analyzing the Economic Impacts of Recreation and Tourism Expenditures Using IMPLAN" (Paper delvered at the Annual meetings of the Regional Science Association, Philadelphia, PA, 1985); D. B. Propst and D. G. Gavrilis, "Role of Economic Impact Assessment Procedures in Recreational Fisheries Management," *Transactions of the American Fisheries Society* 116 (1987): 450-460.

16. Alward and Lofting, "Opportunities for Analyzing"; D. Propst, "Use of IMPLAN with the Public Area Recreation Visitor Survey (PARVS) Pretest Data: Findings and Recommendations" (East Lansing: Michigan State University, November 1985); D. B. Propst, D. G. Gavrilis, H. K. Cordell, and W. J. Hansen, "Assessing the Economic Impacts of Recreation and Tourism: Work Team Recommendations," in D. B. Propst, (compiler), *Assessing the Economic Impacts of Recreation and Tourism: Conference and Workshop* (Asheville, NC: Southeastern Forest Experiment Station, USDA Forest Service); A. E. Watson and L. Bratcher, *Public Area Recreation Visitor Study: Phase III Reporting* (Final cooperative research agreement report to the Southeastern Forest Experiment Station, Athens, Georgia, 1987).

17. Alward and Lofting, "Opportunities for Analyzing"; Propst, "Use of IMPLAN"; Propst et al., "Assessing the Economic Impacts"; Watson and Bratcher, *Public Area Recreation Visitor Study*.

18. Palmer and Siverts, *IMPLAN Analysis Guide*.

19. Walsh, "Recreation Economic Decisions."

20. Ibid.

North American Journal of Fisheries Management 23:835–844, 2003

Estimating the Economic Impacts of a Trophy Largemouth Bass Fishery: Issues and Applications

R. J. CHEN*

Department of Consumer Services Management
University of Tennessee, Knoxville, Tennessee 37996, USA

K. M. HUNT

Department of Wildlife and Fisheries,
Mississippi State University, Mississippi State, Mississippi 39762, USA

R. B. DITTON

Department of Wildlife and Fisheries Sciences,
Texas A&M University, College Station, Texas 77843, USA

Abstract.—We sought to apply economic impact assessment methodology to better understand the local and state-level economic impacts associated with a trophy largemouth bass *Micropterus salmoides* fishery at Lake Fork, Texas. A sample of 848 anglers encountered during creel surveys were sent follow-up mail surveys and asked about their trip expenditures. Creel surveys indicated 74% of anglers were nonlocal state residents, 11% were residents of the three adjacent counties, 10% were from adjacent states, and 5% were other out-of-state anglers. An estimated 204,739 one-person, multiple-day fishing trips were made to Lake Fork between June 1, 1994, and May 31, 1995. We estimate that US$27,487,000 was spent on fishing trips during the study period: $15,783,000 in the local area, $10,637,000 elsewhere in Texas, and $1,067,000 out-of-state. Local residents spent the least per angler/trip ($44) and out-of-state anglers from nonbordering states spent the most per angler/trip ($474). Anglers residing outside of the local area (nonlocal residents and border state and other out-of-state residents) made about $14,540,000 (92%) of the total expenditures in the Lake Fork area. These direct expenditures for local goods and services generated an additional $4,019,871 in economic output, resulting in a total output of $18,559,871 and 367 full- and part-time jobs. The total value-added generated by this increased level of output was estimated at $9,355,999. The total output associated with the fishery at the state level was $9,585,057, and nonresident angler expenditures created 163 jobs in Texas. Besides showing the extent of positive economic impacts of nonlocal fishing activity, these results reveal the extent to which private sector stakeholders benefited from recreational fishing at Lake Fork.

Human dimensions researchers have stressed that anglers seek a diversity of fishing experiences (Driver and Cooksey 1977; Fedler and Ditton 1994). Typically, fishery managers have provided for this diversity through variations in the types of settings they manage (i.e., ponds, lakes, rivers, and streams) and by focusing on managerially relevant species that flourish in those settings. With the increases in fishing pressure that have accompanied human population growth over the past 30 years, however, anglers are demanding even more diversity in their fishing opportunities. No longer satisfied with just a change in fishing locale, anglers want greater variety in the size and number of fish from their desired species that they can catch (fishing quality). This is particularly the case with largemouth bass *Micropterus salmoides* fishing. Even though managers recognize this trend, implementing regimes that provide for this diversity is a difficult task because managing similar water bodies differently will ultimately result in directly or indirectly excluding some anglers at each location. However, this is what must be done if agencies are to enhance fishing quality and maintain high levels of satisfaction within the overall angler population. For many years, trout fisheries management has utilized various rules and regulations to reduce or manipulate angling mortality to provide anglers with the particular fishing quality they seek (see, for example, Deinstadt 1987; Hunt 1987).

From statewide angler surveys, fishery managers in Texas knew that some anglers wanted to catch "a lot of fish" on fishing trips, while others preferred to catch "a few large fish" (Ditton and Hunt 1996). At public hearings in the mid-1970s,

* Corresponding author: rchen@utk.edu

Received January 27, 2002; accepted December 10, 2002

anglers indicated they wanted some relief from the statewide minimum length limits (304 mm) for largemouth bass. This coincided with researchers' acceptance of the idea that bass populations could be manipulated with variations in length limits. Coupled with a boom in reservoir development, Texas Parks and Wildlife Department (TPWD) personnel began to experiment with extended minimum and slot-length limits at the new reservoirs in an effort to develop trophy largemouth bass fisheries for anglers interested in this particular fishing "product" (as they are referred to by Driver 1985).

Accordingly, a lake developed for water supply purposes in northeastern Texas was designed as a fishery for trophy largemouth bass from the outset. In 1978, before impoundment, the Florida subspecies of largemouth bass *Micropterus salmoides floridanus* was stocked in local farm ponds that eventually would be inundated. The reservoir opened in 1980 with a 355-mm minimum length limit and 5 fish/d daily bag limit—both the most stringent limits in Texas at the time. The minimum length regulation was changed in 1985 to a slot-length limit of 355–457 mm and changed again in 1988 to 355–533 mm; the daily bag limit was reduced to three fish in 1992 (only one of which could be longer than 533 mm). In 1998, the slot-length limit was changed again, to 406–609 mm, but the bag limit was extended to five fish (only one of which could be longer than 609 mm) (Hunt and Ditton 1996b). These strategies were designed to initially protect small fish from harvest, then to protect mid-sized fish so they could reach a trophy size, and finally to protect trophy-sized fish and prohibit stunting of the largemouth bass population by encouraging anglers to retain subslot-size fish (Kurzawski 2001). These regulations, along with the bass habitat created by limited tree clearing before impoundment, were intended to produce a quality trophy bass fishery. To date, the 11,211-hectare surface-area reservoir has yielded 35 of the 50 heaviest largemouth bass ever taken from Texas waters, including the current state record of 8.25 kg.

The development of this product-oriented fishery had more farreaching effects than producing large fish and satisfying anglers. Since the first state record fish was caught there in 1986, increases in the numbers of nonlocal and out-of-state anglers at the reservoir were evident from creel surveys and inspection of vehicle license plates at public and private boat ramps (P. Durocher, Texas Parks and Wildlife Department, personal communication). Recognizing that fishing trips made to the reservoir were probably generating extensive economic activity, we initiated this study to better understand the extent of the (largely unintended) economic consequences of developing this recreational fishery.

In particular, we wanted to estimate the extent of local and state-level economic impacts associated with the development of a fishery intended to meet the wants and needs of a particular angler segment: those interested in catching trophy-size largemouth bass. The role of economic impact assessments in reservoir and fisheries development is well established (Weithman 1986; Reichers and Fedler 1996). Total angler expenditures and economic impacts have been quantified at the national level (e.g., U.S. Fish and Wildlife Service and U.S. Bureau of the Census 1997) and at the state level (e.g., Volk and Montgomery 1973; Storey and Allen 1993; Maharaj and Carpenter 1998). Economic impacts of recreational fisheries have been quantified at the local level (e.g., Strang 1970; Martin 1987) and even at the local level for a single species (Brown 1976; Schorr et al. 1995; Bohnsack et al. 2002) but such studies are rare. Likewise, few published studies have used the IMPLAN (IMpact analysis for PLANning) model for assessing the economic impacts of a recreational fishery (e.g., Schorr et al. 1995; Rhodes and Iverson 1998; Steinback 1999; Bohnsack et al. 2002), and all but Schorr et al. (1995) have dealt with marine fisheries. No published results from economic impact studies of local largemouth bass fisheries or, for that matter, of trophy largemouth bass fisheries have appeared previously in the journal literature. Therefore, an assessment of the local and statewide economic impacts of a local fishery at Lake Fork should be useful to fishery managers for project planning and for evaluating the effects of existing reservoir projects in light of project goals.

Study objectives were fourfold: (1) to understand the differential effects of fishing-related expenditures by in-state and out-of-state anglers, (2) to estimate the extent of total economic impacts associated with the development of a new fishery where none existed previously, (3) to identify which business sectors benefit the most from local fishery development efforts, and (4) to better understand the methods, issues, and limitations of economic impact assessments.

Methods

Survey data collection.—We used follow-up mail surveys of anglers encountered through creel surveys to obtain additional information about anglers using a particular water body (Ditton and Hunt 2001). This approach provides an opportunity to explore angler and trip characteristics, as well as expenditures incurred on trips, after the trip has been completed and in greater detail than possible during the creel survey.

Initiating a follow-up mail survey of Lake Fork anglers required a sampling frame. This was accomplished by collecting mailing addresses from anglers who were intercepted on TPWD creel surveys of the reservoir, in addition to standard catch and harvest information. The creel survey was designed as an access-point intercept survey which intercepted anglers at one of four randomly selected public boat ramps for 36 d (9 per quarter) between June 1, 1994, and May 31, 1995 (Lyons and Poarch 1993). Creel results from the previous year suggested that additional sampling days were necessary to ensure a sufficient number of out-of-state anglers were represented. To increase sample size, a creel clerk was randomly assigned to one of the four public boat ramps on every weekend day when TPWD was not conducting a creel survey to solicit additional names and addresses from anglers. A total of 2,200 angler names and addresses were collected from regular TPWD creel sampling and these additional efforts.

Most (N = 1,652) anglers intercepted were nonlocal Texas residents who lived outside of the three counties bordering the reservoir. Because nonlocal Texans would be combined with nonresidents for economic analysis, this number was more than adequate to achieve the desired precision level, that is, a 5% margin of error. Thus, a random sample of 300 nonlocal Texas anglers was selected from this group, which was then combined with the full listing of local Texas anglers (N = 199) and out-of-state anglers (N = 349) for a final sample size of 848 anglers. Oversampling of names and addresses was necessary to obtain a sufficient number of out-of-state anglers for economic analysis. After accounting for survey nonresponse (estimated at 35%), this sample size was considered adequate to be representative of all Lake Fork anglers with a 5% margin of error (Krecjie and Morgan 1970; McNamara 1994).

A self-administered mail questionnaire was developed to collect information from anglers. First, anglers were asked several questions about the fishing trip when they were intercepted by TPWD creel clerks (the date they were intercepted was added to the questionnaire to facilitate respondent recall). Anglers were asked to indicate how many miles they traveled (one-way) to get to the reservoir, whether this was the first time they visited the reservoir, how many days they spent fishing on their trip, the size of their fishing party, and what species they targeted. Next, anglers were asked to indicate how much money they spent within 35 mi of the reservoir or the local area (Hopkins, Rains, and Woods counties) and elsewhere in Texas on their trip for several trip-related items, including automobile transportation, other transportation (e.g., airplane), boat rental, boat operation, boat launch fees, entrance and parking fees, lodging, restaurant meals, groceries, bait and tackle, fishing guide fees, fishing licenses, and other miscellaneous expenses in Texas. Last, out-of-state anglers were asked how much they spent overall outside of Texas on their trip.

Questionnaires were mailed between September 1994 and June 1995 to selected anglers. The mail survey was conducted in four waves immediately after each creel quarter to reduce potential recall bias associated with expenditure items (Hiett and Worrall 1977; Chase and Harada 1984). The subsample of 300 nonlocal anglers was evenly distributed among the four quarters: 75 were included in each wave. Survey procedures were based partly on Dillman (1978) and partly on previous experience with data collection in Texas (Hunt and Ditton 1996a). The survey was personalized to enhance response rate. Three mailings were sent to each angler (as necessary) with a reminder postcard sent 10 d after the first mailing.

Response rates did not differ significantly among the four survey waves (range 72–78%; χ^2 = 2.88, df = 3, P = 0.41), so the results for all four were combined for purposes of reporting results. A total of 619 anglers responded to the mail survey. After excluding nondeliverables from consideration, the effective overall response rate was 74.6%. Returned questionnaires were checked for completeness of response; 10 surveys were returned but were not usable because respondents reported they no longer fished (N = 2), refused to answer (N = 6), or were reported as deceased (N = 2). Another 14 anglers did not provide any economic expenditure data and were removed from the analysis. This left a total of 595 usable questionnaires.

A telephone survey of nonrespondents was used to test for nonresponse bias in the survey results (Bethlehem and Kersten 1985; Fisher 1996). Telephone calling resulted in 39 completed surveys from a sample of 45 nonrespondents (i.e., 20% of nonrespondents). We found no significant differences between respondents and nonrespondents on trip-related items pertinent to the economic analysis: distance traveled on the trip on which they were intercepted by TPWD (t = 0.73, df = 643, P = 0.47), days spent fishing on their trip (t = 0.50, df = 631, P = 0.61), and total expenditures on their trip (t = 0.13, df = 643, P = 0.93).

Economic impact analysis.—This study used an input−output (I−O) IMPLAN modeling system to estimate the economic impacts of a trophy fishery on the Lake Fork region and the state of Texas. The analytical framework for IMPLAN is the I−O economic modeling approach as described by Leontief (1986). The traditional purpose of an I−O model is to provide the quantified interdependent relationships among industries in a regional economy (at local or state levels or both). Miller and Blair (1985) provide a detailed discussion of the advantages and disadvantages of the I−O modeling technique. In addition, for more information about the calculation and limitations of the I−O IMPLAN, readers are referred to the IMPLAN Professional User's Guide (1999).

To ascertain the economic impacts of various management alternatives in contiguous areas, IMPLAN was developed in 1976 by the U.S. Forest Service Land Management Planning Division and Rocky Mountain Forest and Range Experiment Station. The initial application of IMPLAN was designed to calculate the economic impacts of land planning and timber-related management (Chen et al. 2001). In 1997, IMPLAN was modified by the Minnesota IMPLAN Group for estimating economic impacts resulting from various events.

In IMPLAN, yearly data sets are assembled from various secondary sources and industries are categorized into 528 economic sectors based on Standard Industrial Classification codes. IMPLAN allows users to estimate regional economic impacts at the national, statewide, and county level (Chen et al. 2001). Two separate I−O models were used for this study to determine the economic impacts associated with anglers' expenditures. One model focused on the economic impacts of angler expenditures on the three-county local study area; the other estimated the impacts of expenditures on the Texas economy. Within each model, only expenditures by nonresident anglers were counted (those not residing in one of the three local counties for the Lake Fork model and out-of-state residents for the Texas model).

In this study, survey data were used under the IMPLAN models to calculate the economic impacts of a recreational fishery. Residence location was determined from TPWD creel surveys. Using total days of fishing effort estimates from TPWD creel surveys (one-person) and the percentages of anglers by residence location, the total number of days fishing (one-person) was calculated for each residence group. Using average trip lengths for local, nonlocal, border state, and nonborder state anglers as reported in the mail survey, and the total numbers of days fishing per residence group, we calculated the total number of one-person, multiple-day fishing trips for each residence group.

Initial direct expenditures of anglers in the Lake Fork area by nonresident anglers constitute the direct economic effects of the Lake Fork fishery on the local economy. However, direct effects are only one component of the full economic impact of the Lake Fork fishery. Other factors include indirect and induced effects. Indirect effects include economic activity generated among the businesses supplying goods and services to the firms that directly sold their products to visiting angling parties (e.g., additional food supplied to area restaurants for anglers' consumption). Induced effects include economic activity generated by increased local incomes as a result of anglers' expenditures. The sum of direct, indirect, and induced effects constitutes total economic impact. Type I, Type II, and Type III are three types of multipliers available with IMPLAN. Selection among these multiplier types has an important effect on the size of the impacts that are estimated. The Type I multipliers capture the interindustry effects and exclude the induced effects. The Type II multipliers give the direct, indirect, and induced effects in cases where the induced effect works by incorporating labor income and the household consumption into the multiplier. The Type III multipliers measure the direct and indirect and induced effects in cases where the induced effect is based on population. A fundamental problem with the Type III multipliers is that a change in the economy may have reflected a change in productivity or unemployment and does not always result in an increase in population (Minnesota IMPLAN Group 1999). Indeed, for service-intensive exports such as recreation, Type II multipliers are preferred over Type III. Thus, this study used Type II multipliers.

An I−O model can describe the economic importance of a fishery in terms of changes in total industry output, value added, labor income (broken down by employee compensation and proprietor income), and employment (i.e., how much additional employment can be supported by that

TABLE 1.—Number of fishing trips, average trip length, and days of participation at Lake Fork, Texas, from June 1, 1994, to May 31, 1995, by angular residence.

Angler type	Number of boat trips	Average trip length (d [SD])	Number of days fishing
Residents of the Lake Fork area	27,953	1.32 (0.12)	36,898
Texas anglers who live outside the Lake Fork area	161,948	1.59 (0.12)	257,457
Out-of-state anglers from bordering states	11,714	2.98 (0.09)	34,908
Out-of-state anglers from nonbordering states	3,124	6.04 (1.07)	18,838
All anglers	204,739		348,181

spending). Total industry output is the dollar value of all goods and services produced to satisfy final demand for goods and services and the interindustry transactions needed to produce them. Output can also be thought of as a value of sales plus or minus inventory (Minnesota IMPLAN Group 1999). Final demand is the dollar value of purchases from producing industries for final consumption. Value added is the difference between purchased inputs and the value of goods and services produced; it includes salary and wages, state and local tax revenue, nonwage employee compensation, federal tax revenues, profits, and net interest.

The aggregate total effects of changes are calculated by matrix inversion, which estimates economic multipliers that reflect direct, indirect, and induced impacts. An assessment of the total economic impacts of angler economic activities must consider the sum of direct, indirect, and induced activities. At each round of spending, some dollars leak from the local economy. Leakages in an I−O model are typically defined as import purchases, taxes, or savings—all of which remove dollars from the initial spending stream as it passes from sector to sector. Calibration of leakages is critical because it affects the size of the multipliers. Because the Lake Fork fishery could require additional expenditures by local county governments for public services such as law enforcement, water supply, and waste treatment, tax income generated locally by anglers must be considered. Indirect business taxes (consisting primarily of excise and sales taxes paid by individuals to business) generated by angler expenditures will probably contribute to local counties through various business sectors.

Results

Overall, 74% of anglers fishing Lake Fork were nonlocal Texans, 10.6% of anglers were local residents from the three adjacent counties, 10% were from adjacent border states (Arkansas, Louisiana, and Oklahoma), and 5.4% were other out-of-state anglers. We estimated 204,739 one-person, multiple-day fishing trips were made to the reservoir between June 1, 1994, and May 31, 1995. Accordingly, nonlocal Texas anglers accounted for most of the fishing trips (79.1%), and out-of-state anglers accounted for 7.2% of the trips at Lake Fork (Table 1). Local residents spent the least per angler per trip (US$44) in the Lake Fork area, whereas out-of-state anglers from nonbordering states spent the most there per angler per trip ($474), nearly two-thirds more than out-of-state anglers from bordering states (Table 2).

Nonresidents of the Lake Fork area accounted for 89.4% of all anglers. Nonlocal Texans made up 82.7% of nonresidents, and border state and non-border-state anglers made up 11.2% and 6.1%, respectively. Using weighted proportions, nearly 23% of the direct expenditures made in the Lake Fork area were for "lodging" and 19% were for "recreation, fishing, and boating fees." Other substantial categories of expenditures were for "eating and drinking" and "transportation," which

TABLE 2.—Average trip-related expenditures (U.S. dollars) per angler per trip for a Lake Fork fishing trip from June 1, 1994, to May 31, 1995.

Angler type	Average expenditures in Lake Fork Area (SE)	Average expenditures elsewhere in Texas (SE)	Average expenditures out-of-state (SE)
Residents of the Lake Fork area	44.46 (4.62)	7.22 (3.76)	
Texas anglers who live outside the Lake Fork area	59.51 (5.02)	58.29 (15.13)	
Out-of-state anglers from bordering states	292.19 (14.93)	39.79 (5.78)	52.24 (4.91)
Out-of-state anglers from nonbordering states	473.74 (42.26)	169.27 (71.68)	145.75 (91.79)

TABLE 3.—Expenditures (U.S. dollars) by anglers for Lake Fork fishing trips from June 1, 1994, to May 31, 1995.

Angler type	Expenditures in Lake Fork area	Expenditures elsewhere in Texas	Expenditures out-of-state	Total expenditures
Residents of the Lake Fork area	1,243,000	202,000		1,445,000
Texas anglers who live outside the Lake Fork area	9,638,000	9,440,000		19,078,000
Out-of-state anglers from bordering states	3,422,000	466,000	612,000	4,500,000
Out-of-state anglers from nonbordering states	1,480,000	529,000	455,000	2,464,000
All anglers	15,783,000	10,637,000	1,067,000	27,487,000

made up nearly 18% and 17% of total expenditures, respectively. Of the total angler expenditures ($15,783,000) made in the Lake Fork area, $14,540,000 (92%) was spent by anglers residing outside of the local area and was included in the local three-county I–O model (Table 3).

Most of the economic effects were generated in the tourism sectors of hotels and lodging, eating and drinking, and recreation services (e.g., boat rentals, boat operation, boat launch fees, fishing guide fees, and fishing licenses). In turn, these expenditures generated additional expenditures by local service providers, such as restaurant and hotel employees, from tips and direct payments for services, which provided additional economic stimulant. The $14,540,000 in direct expenditures made by nonresident anglers (nonlocal, border state, and other non-Texas residents) for local goods and services generated an additional $4,019,871 in economic output, resulting in a total output of $18,559,871 and 367 full- and part-time jobs associated with or generated by this fishery (Table 4). The average output multiplier was 1.28; that is, every dollar spent in the economy generated $1.28 totally. The total value-added generated by this increased level of output was estimated to be $9,355,999. This is smaller than the total output figure because it represents only the amount of income and taxes retained in the three counties surrounding the reservoir. Many of the interindustry inputs such as labor, capital, and wholesale supplies had to be purchased from outside the region. Each of those outside purchases represents "leakage" from the local economy. The more leakage in an economy, the smaller the economic multiplier and the overall economic impacts from changes in final demand. A component of the total value-added impact generated estimated the impact on labor income at $5,912,242 (Table 4).

The fishery had a smaller economic impact at the state level, because only 15.4% of the anglers were not Texas residents (Table 3). Nearly 34% of the direct expenditures made in Texas by nonresident anglers were for lodging, 17% for recreation, fishing, and boating fees (Table 5). Other substantial categories of expenditures were for eating and drinking and transportation, which made up nearly 17% and 16% of total expenditures, respectively. The total output associated with the fishery at the state level was $9,585,057. Finally, $3,361,551 in labor incomes and 163 jobs were contributed to the state of Texas by Texas nonresident anglers.

TABLE 4.—Impacts of angler expenditures on the local economy (Hopkins, Rains, and Woods counties, Texas) from June 1, 1994, to May 31, 1995. Industry output, value added, and labor income are in U.S. dollars; employment is number of jobs.

Sector	Industry output	Value added	Labor income	Employment
Agriculture	946,578	327,639	252,704	22.4
Mining	171,469	88,368	13,129	0.2
Construction	205,202	107,037	99,893	3.5
Manufacturing	1,292,717	405,742	254,654	6.3
Transportation, communication, and utilities	842,049	512,191	224,494	4.6
Trade	2,316,072	1,802,360	1,119,381	59.1
Eating and drinking	2,723,401	1,313,367	925,425	84.2
Finance, insurance, and real estate	1,545,051	1,205,033	627,523	33.9
Hotels and lodging	3,023,700	1,677,525	1,094,055	76.6
Services	2,715,675	1,168,779	823,664	38.8
Boating and recreation	1,116,139	677,629	412,837	34.7
Government	117,616	61,193	55,348	1.3
Other	9,136	9,136	9,136	1.4
Institutions	2,075,069			
Total	18,559,871	9,355,999	5,912,242	367.1

TABLE 5.—Impacts of nonresident angler expenditures on the economy of Texas from June 1, 1994, to May 31, 1995. See the caption to Table 4 for additional details.

Sector	Industry output	Value added	Labor income	Employment
Agriculture	88,250	35,419	23,924	2.0
Mining	92,697	56,292	16,283	0.2
Construction	118,719	65,016	60,047	1.7
Manufacturing	819,733	260,539	152,725	3.7
Transportation, communication, and utilities	474,249	293,700	139,976	2.5
Trade	997,562	765,652	471,696	20.1
Eating and drinking	1,032,472	526,421	370,933	29.4
Finance, insurance, and real estate	944,515	713,027	294,109	10.0
Hotels and lodging	2,010,972	1,212,284	790,760	37.4
Services	1,526,521	902,984	698,965	25.2
Boating and recreation	813,666	482,284	293,850	29.1
Government	112,611	59,467	43,403	1.0
Other	4,881	4,881	4,881	0.6
Institutions	548,209			
Total	9,585,057	5,377,967	3,361,551	163.0

(Table 5). Because expenditures by Texas residents were excluded from the Texas model, fewer total expenditures ($5,897,000) were included. The average output multiplier (1.62) was greater than the local multiplier because the statewide model captures more interindustry activity (i.e., the amount of economic leakage is smaller because the region of concern is larger).

Total direct and induced industry outputs in the taxable sectors (indirect expenditures are interindustry transfers and are not taxable in Texas) resulted in total tax revenue of $2,689,025 to the three local counties. Thirty-five percent of indirect business tax impacts were generated by trade and retail goods, 17% by hotels and lodging places, and 17% by eating and drinking categories.

Discussion

Trip expenditures by local and nonlocal anglers were comparable to those from other freshwater fisheries (Anderson et al. 1986; Schorr et al. 1995). The distribution of local (11%), nonlocal state resident (74%), and out-of-state (15%) anglers at Lake Fork was not comparable to those of other previously studied freshwater fisheries. Nearly twice as many (an estimated 40%) Lake Texoma anglers, for example, were from the local "impact region," and the rest were nonlocals or from out-of-state (Schorr et al. 1995). At Devil's Lake in North Dakota, local anglers, nonlocal anglers, and out-of-state anglers were responsible for 20, 66, and 14% of total fishing trip-related expenditures, respectively. Had Lake Fork been managed under the generic statewide largemouth bass regulations instead of trophy bass limits, it would probably not have "competed" as well against other largemouth bass fishing destinations in the region, it probably would have attracted mainly local anglers, and this study probably would not have been done. Other destinations would have been closer to home than Lake Fork for many and hence cost less for anglers residing in Texas as well as those from out of state. Given no differences in the quality of fishing experience afforded, we would expect these lower trip-cost alternatives would have been used more frequently than the higher-cost Lake Fork experience (Loomis and Walsh 1997). But Lake Fork was designed to yield a unique type of fishing experience and because of this, anglers are apparently willing to incur additional travel costs and bypass other largemouth bass fishing destinations closer to home to be able fish at a location that suits their particular needs.

This paper provides a more conservative and detailed understanding of the economic impacts of a recreational fishery than available in many of the previously conducted studies of freshwater fisheries. Some have used I–O models such as IMPLAN and RIMS (Anderson et al. 1986; Schorr et al. 1995; Steinback 1999; Bohnsack et al. 2002); others have been "quick and dirty" analyses based on state-level impact multipliers derived from the 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Fish and Wildlife Service and U.S. Bureau of the Census 1997) or approximate multipliers from other sources. The practice of using a single multiplier wrongly assumes that all economic sectors have similar multiplier effects. An initial analysis of economic impacts at Lake Fork, for example, used single local (2.2) and state-level (3.0) multipliers to estimate indirect and induced impacts, respectively

(Hunt and Ditton 1996b). The resulting estimates of local and state-level total industry output impacts were 72% and 85% higher, respectively, than reported here using IMPLAN and their respective data files for county-level and state-level economies. Furthermore, Hunt and Ditton (1996b) were unable to determine which business sectors of the economy were impacted and to what extent by the indirect and induced impacts of angler expenditures.

Whereas we excluded all local and Texas residents when we completed our assessment of economic impacts, this has not always been the case with other economic impact assessments of recreational fisheries. In calculating the regional economic impact of the Devil's Lake fishery in North Dakota, for example, Anderson et al. (1986) used three residency-based scenarios, ranging from the conservative (the economic impacts of nonresidents only) to the optimistic (the economic impacts of locals, nonlocals, and nonresidents) to produce three different estimates of economic impact. Our approach closely approximated the assumptions of the middle scenario used by Anderson et al. (1986), which focused on the economic impacts of nonlocal and nonresident anglers. In contrast, when Schorr et al. (1995) calculated the effects of angler expenditures on the Lake Texoma regional economy, data for regional residents (locals) were included in the final overall estimate of total economic output ($57.4 million).

This analysis also revealed the extent to which respective private sector stakeholders benefit from fisheries. In this case, for example, the largest beneficiaries of the economic impact in terms of the number of part- or full-time jobs at Lake Fork were the hotels and lodging and the eating and drinking sectors. These results are fairly typical for other outdoor recreation activities as well (English and Bowker 1996; Loomis and Walsh 1997). Because these sectors have the most to lose, we would expect their representatives to want to be heard on any proposed changes in fishery rules and regulations that might impact the extent and distribution of current angler clientele. Further, this perspective is in keeping with a social definition of a "fishery" that includes not only fish but also anglers and all other businesses and related infrastructure involved in the provision of recreational fishing opportunities (Ditton 1996).

The total value-added component of economic output (Tables 4 and 5) and its labor component (salaries and wages) are probably more meaningful measures of the economic impact of angler expenditures at a reservoir, for example, than are overall output figures (Crompton and McKay 1994). Accordingly, with regard to related public sector developments, managers can expect the public to be more concerned with how much more income they will earn from nonlocal expenditures than with the extent of expenditures or total economic output.

Consistent with previous economic impact studies of recreational fisheries (Anderson et al. 1986; Schorr et al. 1995; Steinback 1999; Bohnsack et al. 2002), we did not investigate any of the negative effects that may have accompanied this fishery, although we should have done so to provide a more balanced perspective. In addition to estimates of local expenditures and their total economic impact, some consideration needs to be given to the costs of this facility and related activity to local governments and residents (Stokowski 1996). Negative impacts can be physical and environmental, economic, and social in nature (Pizam 1978). Negative physical and environmental impacts can include increased traffic densities and reduced accessibility. Negative economic impacts can include escalation in land prices, employment fluctuation, and dependency on a single industry. Negative social impacts can include crowding and congestion caused by increased fishing activity, introduction of undesirable activities, excessive concern for material gain, and loss of cultural identity. Accordingly, we would expect stakeholders to take these negative aspects into account in assessing the impacts of fishery developments and discount expected positive benefits accordingly.

Several final cautions are necessary. First, the reader is encouraged not to generalize study results to other bodies of water inhabited by largemouth bass or even to those with regulations in place that seek to promote a trophy largemouth bass fishery. Every water body is unique in terms of its resource capability, proximity to angler populations, extent of current use, and competition from other fishing destinations. Whether it will attract nonlocal in-state and out-of-state anglers to the same extent should be a planning objective, with exact outcomes remaining to be seen from a study similar to this one. Second, our analysis focused solely on the economic impact of nondurable goods and services; it did not include expenditures associated with the purchase of boats, motors, trailers, and overall fishing equipment, for example, because these expenditures cannot be attributed solely to a particular fishery, nor could we pro-rate the annual depreciation of the items. Hence, our results were conservative in that they included only direct expenditures for fishing at Lake Fork and their impacts. Third, as has been the case in all previous economic impact analyses of recreational fisheries, we failed to consider changes in the value of land surrounding the reservoir. Future studies of the economic impact of recreational fisheries should include a thorough examination of the changes in public and private assets including land (Stoevener et al. 1974). Finally, for clarification purposes, economic impact assessments are useful for estimating the economic effects of injecting new money into an area. They do not measure an angler's willingness to pay (i.e., net economic benefits) and hence they are not suitable for benefit–cost analyses (Propst and Gavrilis 1987; Edwards 1991).

Acknowledgments

We appreciate the funding support of the Texas Agricultural Experiment Station and the Inland Fisheries Division of TPWD. Federal Aid in Sport Fish Restoration, Grant F-30-R of TPWD provided partial funding for this study. We appreciate the contributions of Phil Durocher, Allen Forshage, Dick Luebke, Ken Kurzawski, Barry Lyons, Steve Poarch, and Robin Riechers of TPWD and David Parsons of the Sabine River Authority of Texas for their involvement in this project. Thanks also go to the TPWD creel survey team of Kirk Pratus and Gary Pickett and to the name collection staff of Ed Cory and Steve Knepper; without their assistance this study would not have been possible. Finally, we thank each of the students in the Human Dimensions of Fisheries Research Laboratory at Texas A&M University who worked on this project.

References

Anderson, R. S., C. J. Schwinden, and J. A. Leitch. 1986. Regional economic impact of the Devils Lake fishery. Fisheries 11(5):14–17.

Bethlehem, J. G., and H. M. P. Kersten. 1985. On the treatment of nonresponse in sample surveys. Journal of Official Statistics 4:251–260.

Bohnsack, B. L., R. B. Ditton, J. R. Stoll, R. J. Chen, R. Novak, and L. S. Smutko. 2002. The economic impacts of the recreational bluefin tuna fishery in Hatteras, North Carolina. North American Journal of Fisheries Management 22:165–176.

Brown, T. L. 1976. The 1973–75 salmon runs: New York's salmon river sport fishery, angler activity, and economic impact. Cornell University, New York Sea Grant Program, Technical Report NYSGP-RS-76-025, Ithaca.

Chase, R. C., and M. Harada. 1984. Response error in self-reported recreation participation. Journal of Leisure Research 16:322–329.

Chen, R. J., J. Fu, and G. Brothers. 2001. Economic impacts of travel to a nature-based regional destination. Consortium Journal of Hospitality and Tourism 5(2):23–36.

Crompton, J. L., and S. L. McKay. 1994. Measuring the economic impact of festivals and events: some myths, misapplications, and ethical dilemmas. Festival Management and Event Tourism 2:33–43.

Deinstadt, J. M. 1987. California's use of catch-and-release angling regulations on trout waters. Pages 49–67 *in* R. A. Barnhart and T. D. Roelofs, editors. Catch and release fishing: a decade of experience. California Cooperative Fishery Research Unit, Humboldt State University, Arcata.

Dillman, D. A. 1978. Mail and telephone surveys: the total design method. Wiley, New York.

Ditton, R. B. 1996. Human dimensions in fisheries. Pages 73–90 *in* A. Ewert, editor. Natural resource management: the human dimension. Westview Press, Boulder, Colorado.

Ditton, R. B., and K. M. Hunt. 1996. Demographics, participation, attitudes, management preferences, and trip expenditures of Texas black bass anglers. Texas A&M University, Human Dimensions of Fisheries Research Laboratory, Report HD-607, College Station.

Ditton, R. B., and K. M. Hunt. 2001. Combining creel intercept and mail survey methods to understand the human dimensions of local freshwater fisheries. Fisheries Management and Ecology 8:295–301.

Driver, B. L. 1985. Specifying what is produced by management of wildlife by public agencies. Leisure Sciences 7:281–295.

Driver, B. L., and R. W. Cooksey. 1977. Preferred psychological outcomes of recreational fishing. Pages 27–40 *in* R. A. Barnhart and T. D. Roelofs, editors. A national symposium on catch and release fishing. California Cooperative Fishery Research Unit, Humboldt State University, Arcata.

Edwards, S. F. 1991. A critique of three "economics" arguments used to influence fishery allocations. North American Journal of Fisheries Management 11:121–130.

English, B. K., and J. M. Bowker. 1996. Economic impacts of guided whitewater rafting: a study of five rivers. Water Resource Bulletin 32:1319–1328.

Fedler, A. J., and R. B. Ditton. 1994. Understanding angler motivations in fisheries management. Fisheries 19(4):6–13.

Fisher, M. R. 1996. Estimating the effect of nonresponse bias on angler surveys. Transactions of the American Fisheries Society 125:118–126.

Hiett, R. L., and J. W. Worrall. 1977. Marine recreational fishermen's ability to estimate catch and to recall catch and effort over time. Human Sciences Research, Research Report HSR-RR/13-CD, McClean, Virginia.

Hunt, K. M., and R. B. Ditton. 1996a. Using survey research in support of fisheries management: the 1994 Texas statewide angler survey. Pages 234–244 *in* L. E. Miranda and D. R. De Vries, editors. Multidimensional approaches to reservoir fisheries management. American Fisheries Society, Symposium 16, Bethesda, Maryland.

Hunt, K. M., and R. B. Ditton. 1996b. A social and economic study of the Lake Fork Reservoir recreational fishery. Texas A&M University, Human Dimensions of Fisheries Laboratory, Report HD-608, College Station.

Hunt, R. L. 1987. Characteristics of three catch-and-release fisheries and six normal-regulation fisheries for brown trout in Wisconsin. Pages 33–48 *in* R. A. Barnhart and T. D. Roelofs, editors. Catch and release fishing: a decade of experience. California Cooperative Fishery Research Unit, Humboldt State University, Arcata.

Krecjie, R. V., and D. W. Morgan. 1970. Determining sample size for research activities. Education and Psychological Measurement 30:607–610.

Kurzawski, K. 2001. A bass act. Texas Parks and Wildlife 59(1):24–29.

Leontief, W. 1986. Input-output economics. Oxford University Press, New York.

Loomis J. B., and R. G. Walsh. 1997 Recreation economic decisions: comparing benefits and costs, 2nd edition. Venture Publishing, State College, Pennsylvania.

Lyons, B., and S. Poarch. 1993. Statewide freshwater fisheries monitoring and management program federal aid in sport fish restoration act. Texas Parks and Wildlife Department, Survey Report for Lake Fork Reservoir, 1992, Project F-30-R-17, Austin.

Maharaj, V., and J. E. Carpenter. 1998. The 1996 economic impact of sport fishing in Texas. American Sportfishing Association, Alexandria, Virginia.

Martin, L. R. G. 1987. Economic impact analysis of a sport fishery on Lake Ontario: an appraisal method. Transactions of the American Fisheries Society 116: 461–468.

McNamara, J. F. 1994. Surveys and experiments in education research. Technomic Publishing, Lancaster, Pennsylvania.

Miller, R. E., and P. D. Blair. 1985. Input-output analysis: foundations and extensions. Prentice-Hall, Englewood Cliffs, New Jersey.

Minnesota IMPLAN Group. 1999. IMPLAN professional: social accounting and impact analysis software. Minnesota IMPLAN Group, Minneapolis.

Pizam, A. 1978. Tourism impacts: the social costs to the destination community as perceived by its residents. Journal of Travel Research 16:8–12.

Propst, D. B., and D. G. Gavrilis. 1987. Role of economic impact assessment procedures in recreational fisheries management. Transactions of the American Fisheries Society 116:450–460.

Rhodes, R. J., and K. G. Iverson. 1998. Economic impacts of a saltwater fishing tournament series in South Carolina. Pages 184–199 *in* 1998 National IMPLAN user's conference proceedings. Minnesota IMPLAN Group, Stillwater.

Reichers, R. K., and A. J. Fedler. 1996. An overview of economic impact and value of recreational fisheries. Pages 245–250 *in* L. E. Miranda and D. R. DeVries, editors. Multidimensional approaches to reservoir fisheries management. American Fisheries Society, Symposium 16, Bethesda, Maryland.

Schorr, M. S., J. Sah, D. F. Schreiner, M. R. Meador, and L. G. Hill. 1995. Regional economic impact of the Lake Texoma (Oklahoma-Texas) striped bass fishery. Fisheries 20(5):14–18.

Steinback, S. R. 1999. Regional economic impact assessments of recreational fisheries: an application of the IMPLAN modeling system to marine party and charter boat fishing in Maine. North American Journal of Fisheries Management 19:724–736.

Stoevener, H. H., R. B. Rettig, and S. D. Reiling. 1974. Economic impact of outdoor recreation: What have we learned? Pages 235–255 *in* D. R. Field, J. C. Barron, and B. F. Long, editors. Water and community development: social and economic perspectives. Ann Arbor Science, Ann Arbor, Michigan.

Stokowski, P. A. 1996. Riches and regrets: betting on gambling in two Colorado mountain towns. University Press of Colorado, Boulder.

Storey, D. A., and P. G. Allen. 1993. Economic impact of marine recreational fishing in Massachusetts. North American Journal of Fisheries Management 13:698–708.

Strang, W. 1970. Recreation and the local economy: am I/O model of a recreation-oriented economy. University of Wisconsin, Wisconsin Sea Grant Program, Technical Report WIS-SG-71-204. Madison.

U.S. Fish and Wildlife Service and U.S. Bureau of Census. 1997. 1996 National survey of fishing, hunting, and wildlife-associated recreation. U.S. Government Printing Office, Washington, D.C.

Volk, A. A., and V. E. Montgomery. 1973. The economic impact of sport fishing in South Dakota, 1972 with notes on angler traits. University of South Dakota, Federal Aid in Sport Fish Restoration Act, Project F-21-R7 and 8, Vermillion.

Weithman, A. S. 1986. Measuring the value and benefits of reservoir fisheries programs. Pages 11–17 *in* G. E. Hall and M. J. Van Den Avyle, editors. Reservoir fisheries management: strategies for the 80's. American Fisheries Society, Southern Division, Reservoir Committee, Bethesda, Maryland.

Ann Reg Sci (2002) 36:247–264

The Annals of
Regional Science

Linking sportfishing trip attributes, participation decisions, and regional economic impacts in Lower and Central Cook Inlet, Alaska

Charles Hamel[1], **Mark Herrmann**[1], **S. Todd Lee**[2], **Keith R. Criddle**[3], **Hans T. Geier**[4]

[1] Department of Economics, University of Alaska Fairbanks, Fairbanks, AK 99775-6080, USA (e-mail: ffmlh@uaf.edu)
[2] National Marine Fisheries Service, Alaska Fishery Science Center, 7600 Sand Point Way NE, Bldg 4, Seattle, WA 98115, USA
[3] Department of Economics, Utah State University, Logan, UT 84322-3530, USA (e-mail: kcriddle@econ.usu.edu)
[4] Department of Natural Resource Management, University of Alaska Fairbanks, Fairbanks, AK 99775-7580

Received: February 2001/Accepted: December 2001

Abstract. Forecasts of the regional economic impacts of changes in the demand for recreation occasioned by regulatory changes, changes in the quality of the recreation experience, or changes in average trip costs require a model that links changes in these trip attributes to individual participation decisions and population participation rates. The probability that an individual will take a particular recreational trip is described using a nonlinear random effects probit model based on variable trip attributes and individual economic and demographic characteristics. These conditional individual probabilities are transformed into predictions of changes in total recreation demand using a simulation-based sample enumeration method. The regional impacts associated with ensuing changes in primary and secondary expenditure patterns are elucidated with a stand-alone recreation-sector module linked to a regionally adjusted zip code-level input-output model. Because the participation model allows for non-constant marginal utility, primary and secondary impacts exhibit nonlinear responses to variations in trip attributes. The modeling approach is demonstrated in an application to the saltwater sport fisheries for Pacific halibut and salmon in Lower and Central Cook Inlet, Alaska.

JEL classification: C25, C67, Q22, Q26

Support for this project was provided by Alaska Sea Grant under grant 98-403 R14-17 and by the Minerals Management Service through the University of Alaska Coastal Marine Institute project 12-35-0001-30661 task order 14196. Additional funds were provided by the Utah Agricultural Experiment Station, journal paper 7395. The views expressed herein are those of the authors and do not necessarily reflect those of the institutions or agencies with which they are affiliated.

1. Introduction

The lure of world-class fresh and saltwater sportfishing opportunities makes Alaska's Kenai Peninsula one of the state's most visited regions. This study examines the regional economic impacts of expenditures related to the saltwater sport fisheries for Pacific halibut (*Hippoglossus stenolepis*), and chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon that take place in the marine waters of Lower and Central Cook Inlet. Most of these trips originate from road-accessible segments of the western shoreline of the Kenai Peninsula. In addition to non-monetary benefits enjoyed by visiting and resident anglers, sportfishing contributes to the economic well being of Kenai Peninsula communities as infusions of new money filter through tourism related businesses and circulate within local economies.

The decision to take a sportfishing trip is predicated on the expectation that the benefits of taking the trip will exceed the associated costs. Consequently, an understanding of how that decision depends on individual demographic characteristics and attributes of the recreation experience allows prediction of how angler behavior will change in response to changes in trip attributes. For example, changes in fish stock abundance that affect catch rates or regulatory measures that affect bag and possession limits will be perceived by anglers as changes in the attribute bundle associated with their fishing trip. Because the likelihood that alternative fishing trips will be taken is expressed in probabilistic terms, confidence bounds around the predicted changes in participation rates and associated changes in regional expenditures can be estimated.

Examples of recent policy initiatives that highlight the need for regional impact analyses to account for the contribution of recreation activities include: damage assessments associated with the *S.S. Glacier Bay* and *S.S. Exxon Valdez* oil spills; potential risks associated with outer continental shelf petroleum development lease sales adjacent to prime commercial and recreational fishing grounds in Lower Cook Inlet and the Gulf of Alaska; and, management decisions to determine the allocations of allowable catches between commercial, sport, and subsistence fishers. Because oil exploration, development, and production activities in Cook Inlet could affect the productivity of adjacent fishing grounds and the quality of recreational activities, economic impact analyses are required to demonstrate the range of potential adverse impacts to communities (Northern Economics 1990; Cohen 1993; MMS 1995; Herrmann et al. 2001a). Another example is the allocation of Pacific halibut between commercial fishermen and sportfishing charterboat operators. Sportfishing in Alaska has increased considerably in the last few decades. Total purchases of fishing licenses have increased from 90,565 in 1961 to 431,894 in 1997. Over the same period, sportfishing catches of Pacific halibut have increased from less than 2% to 18% of total removals. Because Pacific halibut is a fully subscribed fishery with an overall limit on allowable removals, increases in sport catches necessitate concomitant reductions in commercial harvests. Such allocation decisions are subject to statutory and regulatory requirements to consider the effect on net benefits to the nation and the impact on small entities, including communities and small businesses.[1]

[1] Regulatory guidelines for implementation of the Magnuson-Stevens Fishery Conservation and Management Act require that an attempt be made to assess the net economic benefits to the nation of all management actions that affect federally managed fisheries. The Regulatory Flexibility

Estimates of the magnitude of consumer and producer surpluses and associated regional economic impacts are necessary for formal compliance with these requirements (Herrick et al. 1994).

The commercial and sport fisheries of Lower and Central Cook Inlet both contribute to the economic well being of residents of the Kenai Peninsula, Alaska, and the nation. Economic aspects of the commercial halibut fishery have been subject to considerable analysis (e.g., Crutchfield and Zellner 1962; Lin et al. 1988; NPFMC 1991; Homans 1993; Criddle 1994; Herrmann 1996; NRC 1999; Herrmann 2000). Economic aspects of Alaska's commercial salmon fishery have been examined at a similar level of detail (e.g., Herrmann 1993, 1994; Herrmann and Greenberg 1994). In contrast, there has been little formal analysis of Alaska's marine recreational fisheries. Coughenower (1986) provides a qualitative description of the halibut guide/charter fishery. Jones and Stokes (1987) provide a small-sample estimate of the consumer surplus associated with halibut and salmon sportfishing. Northern Economics (1990) provides an estimate of the economic impact of the *S.S. Glacier Bay* oil spill that includes a qualitative discussion of sportfishing benefits. Our study raises the level of sportfishing analysis closer to that available for the commercial fishery. We do so using an econometric model of the determinants of individual participation decisions, a simulation procedure to aggregate across individual decisions and estimate total sportfishing effort, and a regional input-output model that describes primary and secondary expenditure patterns. This approach results in a behaviorally based integrated model of the regional economic impacts of changes in the demand for sportfishing occasioned by, for example, management actions, environmental damage, or natural fluctuations in the abundance of the target species and substitute target species.

2. Data and models

The participation and regional impact models rely on data collected by a postal survey of a random sample of 4,000 anglers who purchased an Alaskan sportfishing license in 1997. The survey solicited socioeconomic and catch data, detailed information regarding expenses incurred on recent salmon and halibut fishing trips, and stated preferences for hypothetical trips. In addition to expenditures directly related to fishing, respondents were also asked to report other trip expenses including transportation and lodging costs. Overall response to the survey exceeded 70%. The survey design, sample frame, and results are described in Herrmann et al. (2001b) and cross-validated with common elements from the Alaska Department of Fish and Game statewide sportfishing harvest survey (ADF&G 1998).

Attributes that affect participation in the Lower and Central Cook Inlet saltwater sport fishery include the number and species of fish caught (including retained and released fish), average catch weight, and trip cost. On an average trip, Alaskans caught 1.71 halibut, 0.19 chinook salmon, and 0.06 coho salmon weighing 34.2, 28.3, and 10.6 pounds each, respectively. The mean

Act requires that the economic impact of proposed federal regulations on small entities be assessed in advance of management action. While these requirements do not specify the methodologies to be used in meeting statutory and regulatory analysis requirements, recent court decisions have set aside management actions based on ad hoc or informal economic assessments.

nonresident trip included catches of 2.43 halibut, 0.14 chinook, 0.31 coho, and average fish weights of 42.7, 30.9, and 9.6 pounds, respectively.

The regional economic impact of sportfishing depends on the number of participants and their expenditure patterns. We grouped recreational fishers into categories because reported expenditures varied substantially across participant origins and sportfishing modes. The residency categories were: Kenai Peninsula Borough residents (local); other Alaskan residents (non-local Alaskan); and, other US citizens (nonresident). The sportfishing modes were: fishing from shore (shore); fishing from a vessel hired for the trip (charter); and, fishing from a vessel that is personally owned or otherwise made available to the trip taker without payment of a rental fee (private). Thus, we model nine distinct expenditure patterns. Mean transportation and living expenses for local residents and other Alaskans ranged between \$30.41 and \$75.66 per day, and from \$62.99 to \$103.87 for nonresidents dependent on fishing mode. Mean living expenditures were lower for nonresidents who fished off private boats than for those who fished from shore or from charter boats, due in part to the fact that the primary trip purpose for many such respondents was to visit friends and family. Mean per-trip fishing expenditures ranged between \$2.14 (shore) and \$137.06 (charter) for local residents. Mean non-local Alaskan sportfishing expenditures varied from \$4.50 (shoreline) to \$129.25 (charter). On average, nonresidents spent \$30.57 to \$190.34 per shore and charter trip, respectively. Detailed information on average daily sportfishing expenditures by category is reported in Herrmann et al. (2001b).

Estimates of 1997 saltwater angling effort in Lower and Central Cook Inlet were obtained from the Alaska Department of Fish and Game annual sport fish statewide harvest survey (ADF&G 1998). Total sportfishing effort was multiplied by the average daily expenditures, disaggregated into time spent on the Kenai and time spent elsewhere in Alaska, and adjusted to reflect trip purpose. The majority (63.5%) of respondents identified fishing for halibut or salmon in Cook Inlet as the primary purpose of their most recent trip. This response was most pronounced for non-local Alaskans, 87.9% of who listed fishing for halibut or salmon in Cook Inlet as the main reason for their trip. Less than half of the nonresidents (43%) identified fishing for halibut or salmon in Cook Inlet as their primary motive. Another important reason (24.4%) for nonresident trips was simply to visit and vacation in Alaska. Freshwater fishing and visiting relatives were also important motives for nonresidents. While the empirical model can be used to estimate the probability that the average angler will take a specified trip, it does not explicitly account for how the probability that a particular angler would take that trip is affected by differences in the primary purpose of that individual's visit to the Kenai Peninsula. To account for these differences, we assumed that individuals who expressed saltwater fishing as the main purpose of their trip would forego their visit to the Kenai entirely if expectations of adverse angling conditions discouraged them from fishing at all. Individuals whose primary trip purpose was to visit friends or relatives, conduct business, or to take a cruise ship voyage or hunting trip were assumed to substitute other activities on the Kenai Peninsula if halibut and salmon saltwater sportfishing conditions were unattractive or unavailable. These assumptions were applied as a downward adjustment to the number of angler days in order to estimate total expenditures that were uniquely attributable to the salmon and halibut sportfishing opportunities in Lower and Central Cook Inlet. The total expenditures in Table 1 can be re-

Table 1. Total 1997 expenditures ($million) attributable to Lower and Central Cook Inlet salt-water sportfishing adjusted to reflect trip purpose

	Spending on Kenai Peninsula	Spending elsewhere in Alaska	Total spending
Fishing expenditures			
Charter fees	$10.366	–	$10.366
Gear	$1.904	$0.074	$1.978
Processing fees	$2.307	–	$2.307
Derby fees	$0.269	–	$0.269
Boat fuel & repairs	$1.732	$0.291	$2.024
Moorage or haul fees	$0.671	–	$0.671
Total fishing expenditures	$17.251	$0.366	$17.617
Ancillary expenditures			
Auto and truck fuel	$2.619	$0.452	$3.071
RV rentals	–	$2.697	$2.697
Lodging	$3.226	$1.015	$4.242
Groceries	$2.864	$0.516	$3.381
Restaurant & bar	$2.561	$0.488	$3.050
Total ancillary expenditures	$11.272	$5.170	$16.443
Total	$28.524	$5.536	$34.061

garded as a measure of the economic significance, in terms of output in 1997 dollars, of the Cook Inlet marine sport fisheries for halibut and salmon. For purposes of generating economic impacts to the western Kenai Peninsula, we begin with a 1997 baseline of $28.5 million. Increased or diminished angler spending will depend on changes in demand for recreational fishing, which is in part, a function of the expected trip attributes. This relationship is explored next.

2.1. *Participation-rate model*

Changes in expected catch or the expected size of fish caught (changes in trip attributes) affect the average sport fisher's decision to participate in (take) a sportfishing trip, regardless of whether the attribute change is due to natural population fluctuations, regulatory change, or environmental damage. That is, changes in fishery regulations, environmental quality, resource abundance, or trip costs, affect participation decisions. In contrast to previous studies (e.g., Holland and Ditton 1992; Aas 1995; Thunberg et al. 1999) that model population-level changes in the demand for recreational fishing based on exogenous demographic characteristics, we modeled the individual participation decision as a binary dependent variable explained by price, demographic characteristics, and angler success expressed in terms of the composition, magnitude, and average size of fish caught. The model can be expressed as:

$$y^*_{it} = \beta_0 + \beta_1 p_{it} + f_1(n_{its}\bar{x}_{its}) + f_2(n_{its}) + f_3(z_{il}) + e_{it} \tag{1}$$

The dependent variable y^*_{it} takes on the value of 1 (0) if individual i with demographic characteristics z_{il} would (would not) have taken trip t with price p_{it} and trip attributes n_{its} and $\bar{x}_{its}$. Where the z_{il} are realizations of categorical variables representing per-capita household income, gender, age, and education for individual i, p_{it} is the price paid by individual i for trip t, n_{its} is the

Table 2. Participation model parameter estimates

	Alaskans (local and non-local)		Nonresidents	
	Estimates	t-ratios	Estimates	t-ratios
Intercept	−2.8415	−3.03*	−1.4746	−1.86
Price	−0.0124	−7.39*	−0.0094	−6.96*
$n_{halibut}\bar{x}_{halibut}$	0.0371	3.30*	0.0228	2.53*
$n_{chinook}\bar{x}_{chinook}$	0.1037	4.32*	0.0732	3.56*
$n_{coho}\bar{x}_{coho}$	0.1242	2.95*	0.1163	3.19*
$(n_{halibut}\bar{x}_{halibut})^2$	−0.0001	−2.88*	−0.0001	−1.33
$(n_{chinook}\bar{x}_{chinook})^2$	−0.0006	−3.41*	−0.0004	−2.52*
$(n_{coho}\bar{x}_{coho})^2$	−0.0008	−1.13	−0.0011	−1.82*
$(n_{halibut}\bar{x}_{halibut})(n_{chinook}\bar{x}_{chinook})$	−0.0005	−3.50*	−0.0004	−3.20*
$(n_{halibut}\bar{x}_{halibut})(n_{coho}\bar{x}_{coho})$	−0.0007	−2.84*	−0.0005	−2.38*
$(n_{chinook}\bar{x}_{chinook})(n_{coho}\bar{x}_{coho})$	−0.0018	−3.60*	−0.0010	−2.26*
$n_{halibut}$	1.1033	2.05*	0.9241	2.33*
$n^2_{halibut}$	−0.1492	−2.19*	−0.1297	−2.52*
Per-capita household income	0.0945	1.09	0.0021	0.04
Gender (1 = male)	0.3853	2.03*	0.0963	0.57
Age	0.0080	1.04	0.0003	0.05
Education (1 = college graduate)	0.2827	1.39	0.3853	2.49*
ρ	0.192	2.77*	0.192	2.77*

* Significantly greater (less) than zero at $p \le 0.05$.

number of fish of species s (halibut, chinook, coho) caught by individual i on trip t, and $\bar{x}_{its}$ is the average weight of fish of species s caught by individual i on trip t. The functions $f_1(\cdot)$ and $f_2(\cdot)$ were specified as simple second order polynomials. Specifically, $f_1(\cdot)$ includes linear and quadratic terms and cross-products for all three species and $f_2(\cdot)$ includes linear and quadratic terms in the number of halibut caught. This specification allows for non-constant marginal utility of catch and substitution/complementarity effects across species. The function $f_3(\cdot)$ was specified as linear and additively separable in all variables.

Survey respondents were presented with trips described by a combination of: one of three costs levels ($100, $170, $240 per day); one of four halibut catch (keep and release) levels (0, 2, 4, 6 fish per trip); one of four average halibut weights (0, 20, 40, 80 lbs per fish); one of three chinook catch levels (0, 1, 2 fish per trip); one of four average chinook weights (0, 15, 25, 50 lbs per fish); one of four coho catch levels (0, 2, 4, 6 fish per trip); and one of two average coho weights (0, 7 lbs per fish). Efficient specification of hypothetical trip attributes, and survey design and administration are described in Hermann et al. (2001a).

Equation (1) was estimated using a random effects probit model following Butler and Moffitt (1982). This model accounts for both the discrete and panel nature of the data. Fully interactive indicator variables were used to estimate separate parameters for Alaskans and nonresidents. Because the same general study design was presented to each group, only one random effect parameter, ρ, was estimated. Estimates of the 35 parameters and associated t-statistics are reported in Table 2. Twenty-six of the parameters are significantly greater (less) than zero at the 5% level and the point estimates of the parameters and their signs accord well with economic theory: the price coefficients are significantly less than zero; the coefficients on halibut, chinook, and coho weights and halibut catches are significantly greater than zero; the weight and catch squared terms are all negative, implying that anglers experience decreasing marginal utility; and, the cross-products of the weights of halibut, chinook, and coho are significantly less than zero, suggesting that catches of each species are substitutes for catches of the others. The presence of an identifiable random effect is supported by the statistical significance of the estimated parameter. With the exception of gender in the Alaskan equation and education in the nonresident equation, the demographic characteristics were not statistically significant.

Model forecasts are based on the sample enumeration method (BenAkiva and Lerman 1987), which takes into account differences in socioeconomic characteristics and variability in the number of days fished per year by developing forecasts for each individual in the sample. This information is used to weight the simulations by the number of days fished:

$$\%\Delta Participation_\alpha = \frac{\sum_i[\Phi(\hat{u}_{i,1})days_i] - \sum_i[\Phi(\hat{u}_{i,0})days_i]}{\sum_i[\Phi(\hat{u}_{i,0})days_i]}. \tag{2}$$

Where $\hat{u}_{i,j}$ is the forecast of indirect utility for individual i taking a fishing trip characterized by attributes j, $j = 0$ denotes the initial or starting point fishing trip attributes and $j = 1$ denotes the new fishing trip attribute levels based on an α percent change from the $j = 0$ levels, $\%\Delta$ is used to signify percentage change, $\Phi(\cdot)$ is the cumulative normal distribution function, and $days_i$ is the number of days individual i fished in marine waters off the Kenai Peninsula in 1997. Confidence intervals around the separate estimates for Alaskan resident and nonresident participation-rate levels were generated following Krinsky and Robb (1986).

2.2. *Input-output model*

Input-output models have been widely used to evaluate the regional impacts of development projects and regulatory policy changes. Examples include assessments of the impacts of changes in National Forest harvest policies (Summers and Birss 1991), federal grazing policies (Geier and Holland 1991), community development strategies (Geier et al. 1994), and regulatory changes in management of commercial crab fisheries off Alaska (Natcher 1996) and guided sport fisheries off New England (Steinback 1999).

We selected IMPLAN (Olson and Lindall 1997) as a base for our model. IMPLAN includes a representation of 21 economic and demographic variables for each of 528 industrial sectors. We obtained zip-code area level IMPLAN data sets, the smallest geographical resolution available for coverage of the western Kenai Peninsula. In regions such as Alaska, with small numbers of firms (frequent disclosure problems), and a rapidly evolving and heavily resource dependent economy, it is particularly essential that the transaction coefficients be groundtruthed to the greatest extent practicable. Consequently, team members spent two weeks in the study region meeting with individuals, business owners, industry representatives, and local government officials for purposes of improving the original database. Zip-code area level corrections to the output and value added components for each of the

138 IMPLAN sectors active in the Kenai Peninsula region are detailed in Herrmann et al. (2001a).

Because recreational fishing is not explicitly represented in IMPLAN, we developed a programming module to disaggregate IMPLAN sectors that include recreation-based activities to highlight activities generated by recreational fishing (Hamel et al. 2001). This module utilizes IMPLAN generated response coefficients and secondary regional economic data as inputs in model formulation. The secondary model data is augmented with data for the target sectors (e.g., sport/charter industry) supplied from primary and secondary sources as well as discussions with industry representatives. Thus this module, through its input-output framework, explicitly accounts for linkages between various economic sectors, according to production and consumption patterns. Individual sportfishing activities are accounted for by expenditure patterns in retail and service sectors rather than treated as direct income generating activities such as guiding, harvesting, and processing. The recreational fishing module allocates recreational expenditures among these newly represented sectors. The sportfishing expenditure data were obtained from responses to the angler survey described above. The operating cost data required for modeling charter operations were derived through discussions with charter operators and industry representatives.

In contrast to manufacturing sectors, which are well represented in IMPLAN, retail sectors are highly aggregated. Because impacts associated with changes in sportfishing related expenditures are transacted primarily at the retail level, tracking them requires disaggregation of some of the IMPLAN sectors. While aggregating two or more IMPLAN sectors is straightforward, there are many consistent ways to disaggregate sectors. For example, while charter trip payments are included in IMPLAN's Amusement and Recreation Services sector, a catch-all designation for 106 types of recreational activities, it is not possible to know how to correctly adjust the vector of technical coefficients to isolate transactions specific to guided sportfishing without information describing the intermediate demand components associated with charters. Although it might be tempting to represent a newly constructed "Charter" sector with a vector of technical coefficients generated as a simple fraction of the Amusement and Recreation sector, doing so would render the technical coefficients matrix singular and preclude model solution. Moreover, a "Charter" sector production function derived as a linear combination of other sectors would bear little resemblance to the specific input requirements of the guided sport fishery.

Bushnell and Hyle (1985), Wolsky (1984), and Gillen and Guccione (1990) suggest approaches that directly modify the technical coefficients matrix. Steinback (1999) offers a straightforward yet data intensive solution by creating new sectors of interest within the IMPLAN framework, and reprogramming the model's social accounting matrices to reflect the characteristics of the disaggregated subsector. By including the new sector within the model, the changes are noted within the use (absorption), byproducts, and final demand matrices. Regional purchase coefficients and value-added features are similarly constructed for the new sector. Jensen (1997) addresses the disaggregation problem by running impact scenarios in IMPLAN to mimic the input requirements for the subsector of interest, thereby simulating the intermediate demands. Using IMPLAN's front end, a demand shock is executed with components (events) that mirror the proportions of the simulated sector's

Table 3. Parameters values for the estimated average production function for the marine charter sector

Expense category	Coefficient	Expense category	Coefficient	Value added category	Coefficient
Advertising	0.0410	Medical	0.0015	Employee comp	0.1147
Bait	0.0133	Office supplies	0.0135	Proprietor income	0.1949
Computer total	0.0066	Professional services	0.0098	OPTI	0.0339
Contract services	0.0035	Repair/maint/ tools/supplies	0.0130	Indirect bus tax (sales tax)	0.0306
Dues	0.0139	Subscriptions	0.0018		
Electronic supplies	0.0004	Total boat maintenance	0.0132		
Entertainment	0.0009	Total borough tax	0.0369		
Fed income tax	0.0416	Total insurance	0.0392		
Fuel & lubrication	0.1356	Total licenses	0.0243		
Gear replacement	0.0216	Total travel	0.0181		
Groceries	0.0008	Total truck exp	0.0178		
Hull repair	0.0054	Total utilities	0.0380		
Interest paid (boat)	0.0542	Trade shows	0.0214		
Moorage & boat storage	0.0182	Work gear/client supplies	0.0202		
Absorption coefficient			0.6259	Value Added Coefficient	0.3741

production function. The resulting impacts can then be used to calculate response coefficients (normal multipliers). However, because the new subsector is not explicitly defined in the IMPLAN framework, there is no opportunity for it to play a role in the intermediate demand of other sectors within the model, thus leading to possible underestimation of indirect and induced effects.

A model of the average charter operation's expenditure patterns was constructed using data reported in NPFMC (1997, 2000) as well as discussions with local experts and members of industry. Standard Industrial Classification (SIC) codes for the corresponding inputs were translated to the IMPLAN sectoral scheme and a production function was estimated for the 1997 charter sector sales value of $13.6 million, based on average per day charter fees and Alaska Department of Fish and Game estimates of charter client days (see Herrmann et al. 2001a). The SIC based coefficients were aggregated according to their corresponding IMPLAN sectors to provide an estimate of the average production function for the marine charter sector (Table 3). These technical coefficients were applied to the baseline charter sales data to obtain the coefficient values reported in Table 4. (For a more detailed accounting of the individual expense categories, corresponding SIC codes and translation to the IMPLAN sectoral scheme, see Herrmann et al. 2001a). Impact scenarios were run in IMPLAN to generate response coefficients for all other expenditure categories. These response coefficients and those developed for the charter operation sector were then integrated into the stand-alone recreational module (Herrmann et al. 2001a). Where data limitations prevented construction of

Table 4. Absorption sectors and coefficients for sportfishing expenditure categories

Expenditure category	IMPLAN sector #	IMPLAN sector name	Coefficient
Transportation, food & lodging			
Auto or truck fuel	451	Automotive dealers & service stations	1.00
Groceries	450	Food stores	0.75
	455	Miscellaneous retail	0.25
Lodging	463	Hotels and lodging places	1.00
Restaurant & bar	454	Eating & drinking	1.00
Fishing expenditures			
Boat fuel, lubricants & repairs	393	Boat building and repairing	0.10
	448	Building materials & gardening	0.05
	451	Automotive dealers & service stations	0.70
	455	Miscellaneous retail	0.10
	482	Miscellaneous repair shops	0.05
Charter & guide fees		Table 6	
Fish processing or packaging	98	Prepared fresh or frozen fish or seafood	1.00
Fishing derby entry fees	503	Business associations	1.00
Fishing gear	98	Prepared fresh or frozen fish or seafood	0.15
	421	Sporting and athletic goods, n.e.c.	0.05
	449	General merchandise stores	0.20
	455	Miscellaneous retail	0.50
Haul out & moorage fees	435	Motor freight transport and warehousing	0.10
	436	Water transportation	0.45
	451	Automotive dealers & service stations	0.10
	473	Equipment rental and leasing	0.15
	479	Automobile repair and services	0.20

original production functions, the model defaults to the values reported for input coefficients in Jensen (1997).

To be useful, impact models should be linked to a demand model for the activity in question. Although an accurately groundtruthed input-output model may correctly predict the regional impact of a given change in the number of sportfishing trips taken, that capability is of limited value in the absence of a companion model for predicting how the number of sportfishing trips varies as a function of observable or controllable trip attributes. That is, for an impact model to serve as a tool for evaluating the effects of management actions, fluctuations in resource abundance, or environmental damages, it is essential to know how those attributes affect participation rates. The relevancy of our impact simulations arises from the empirically (behaviorally) based model of participation decisions.

3. Simulations and software

Estimated baseline expenditures and effort were combined with the IMPLAN generated response coefficients and the participation rate model to form an integrated impact model as illustrated in Fig. 1. Designed as a stand-alone module,

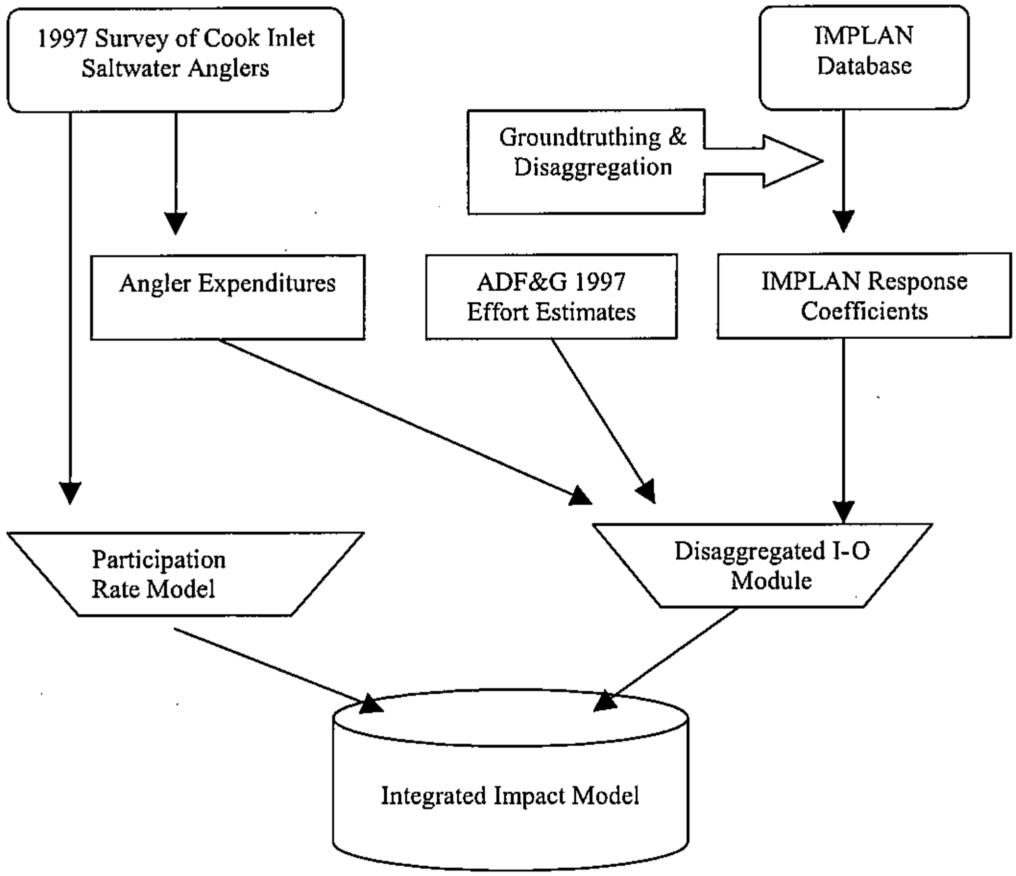


Fig. 1. Modeling components of the integrated impact model

the software (Hamel et al. 2001) provides a user friendly front-end for analysts to simulate the economic impacts of changes in angler spending to the western Kenai Peninsula. The impacts are expressed in terms of output (sales), income, employment, and other value added variables. Altered spending behavior is driven by changes in participation, which are determined by changes in trip attributes (e.g., fish catch and size, and trip cost). We apply the resulting percentage changes in effort, by residency and fishing mode, on a one-to-one basis to baseline angler-day expenditures that are directly attributable to sportfishing.

The simulations begin with the probability that the average angler will take a sportfishing trip, given a set of trip attributes. Regional economic impacts are measured in relation to a baseline of expenditures and vary as sport fishers respond to changes in fishing trip attributes. Each of the nine categories of sport fishers (nonresidents and local and non-local Alaskans engaged in charter or personal vessel and shore based fishing modes) is represented by a distinct expenditure pattern in the integrated model. We begin with the baseline of $28.5 million in total spending on the western Kenai (Table 1). This value can be regarded as a measure of the economic significance of the marine sport fishery in terms of sales, or output. However, this value includes spending by local residents. Because we assume that local residents freely substitute between sportfishing and other regional recreational activities, their expenditures need to be netted out. Subtracting the spending of Kenai Peninsula

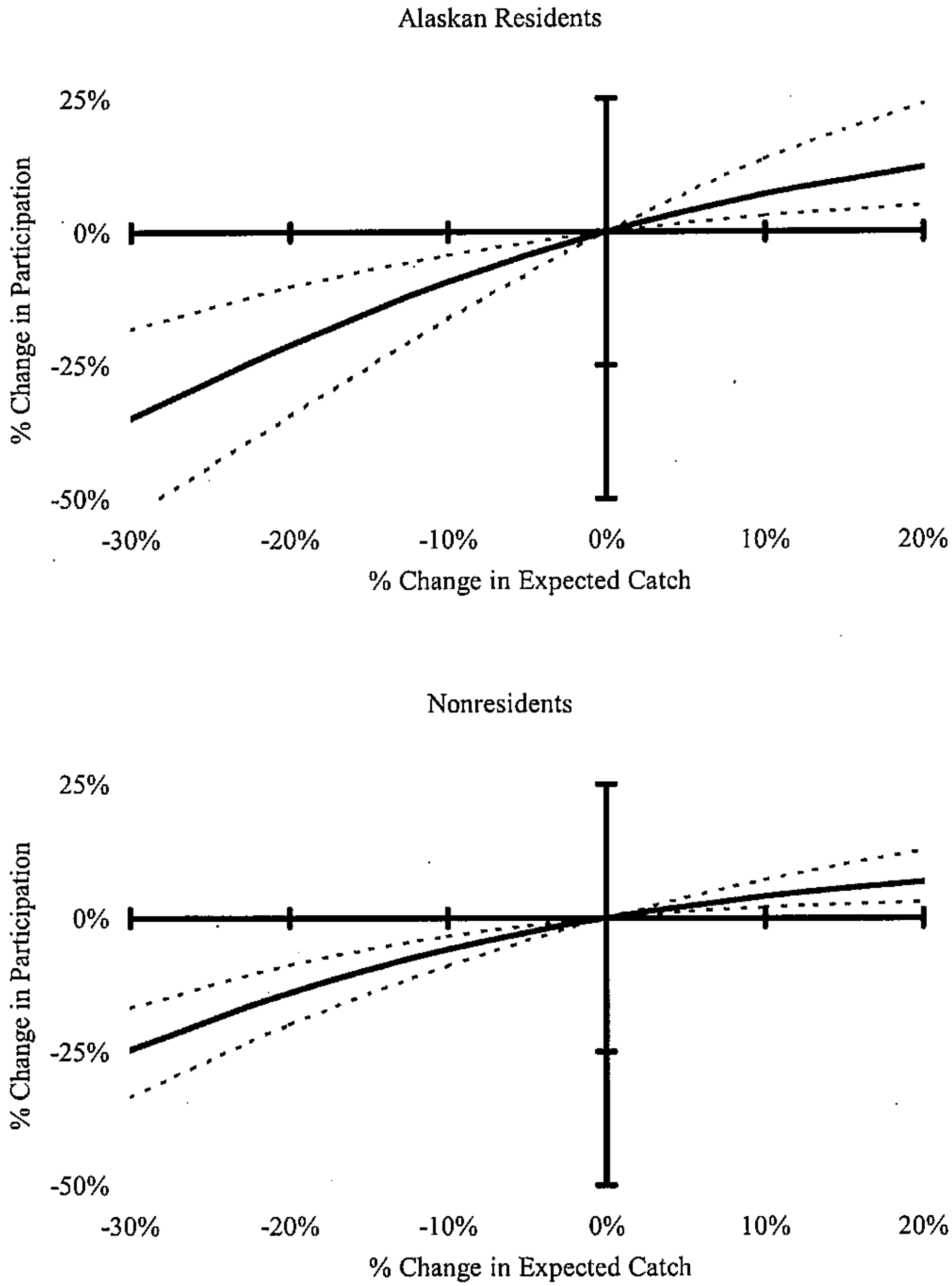


Fig. 2. Percentage changes in days fished by resident and nonresident anglers resulting from changes in the expected sportfishing catches. (90% confidence intervals are represented with *dotted* lines)

Borough residents from the total expenditures attributable to the Lower and Central Cook Inlet sport fisheries leaves \$25 million of "new" money; money spent by non-local Alaskans and nonresidents. Fishing related and other expenditures amount to \$15.3 million and \$9.7 million, respectively.

Increases in the amount of new money spent locally stimulate economic activity whereas decreased spending by non-locals leads to a reduction in economic activity. Variations in spending by non-locals are driven by the

Table 5. Estimated regional economic impacts of changes in expected catch ($)

% Change in catch	% Change in participation	Change in angler expenditures	Change in output ($)	Change in personal income ($)	Change in employment (jobs)
−30%	−31.3%	−6,962,057	−10,062,164	−4,245,863	−292
−20%	−18.5%	−4,026,681	−5,819,726	−2,456,990	−168
−10%	−8.0%	−1,718,435	−2,483,646	−1,049,021	−72
0%	0.0%	0	0	0	0
+10%	+5.9%	1,225,825	1,771,687	748,812	51
+20%	+10.0%	2,068,612	2,989,775	1,263,986	86

changes in effort predicted by the participation rate model. For every percentage change in effort measured by reduced or increased sportfishing-days, there is a proportional change in daily expenditures across each of the residency and sportfishing mode categories. The changed expenditures are summed and multiplied by the response coefficients to generate estimates of the economic impact of regulatory or environmentally induced changes in fishing trip attributes. The impacts are calculated in terms of output, employment, employee earnings, proprietors' income, personal income, other income, indirect taxes, and value added for direct, indirect, and induced effects.

Figure 2 depicts the response of resident and nonresident demand for sportfishing to changes in expected catch levels. The associated regional impacts are reported in Table 5 and represented in Figures 3–6. For example, a 10% reduction in expected catch results in an 8% decrease in overall effort; the weighted average of a 9.3% decrease in resident effort and a 5.8% decrease in nonresident effort. The reduction in resident and nonresident trips results in a $1.7 million decrease in 'new' money spent, and lead to direct, indirect, and induced impacts of −$2.5 million in output, −$1.0 million in personal expenditures, and a net loss of 72 jobs. Note that the impact is nonlinear and that the marginal impact declines as catch increases. That is, there is a larger decline in expenditures and jobs when moving from a 20% decrease to a 30% decrease in expected catch than when moving from a 20% increase to a 10% increase. This result is consistent with the principle of declining marginal utility where utility, and therefore participation, increases at a decreasing rate with incremental changes in angler success.

The software module used to calculate changes in economic activity from hypothetical changes in expected trip attributes is described in Hamel et al. (2001). The model allows users to simulate changes in expected fish catch, size, and trip costs and to isolate these effects to the economic activities of specified fishery modes (charter, private, shore). Although the module was groundtruthed to 1997 values, it can be applied to more recent periods by incorporating updated effort data and using an inflation index. For example, in 1999 when the total fishing days on the lower Cook Inlet was 185,114 angler days, it is estimated that nominal expenditures of $23.5 million was spent in the region by non-local Alaskans and nonresidents ($14.1 million in fishing related expenses and $9.4 million in other expenses). However, these dollar estimates still hinge on 1997 survey data for individual expenses, as would all future estimates until a new survey is undertaken. Because the 1999 estimated expenditures are slightly lower than in 1997, the resulting effects of changes in expected catches are be slightly less.

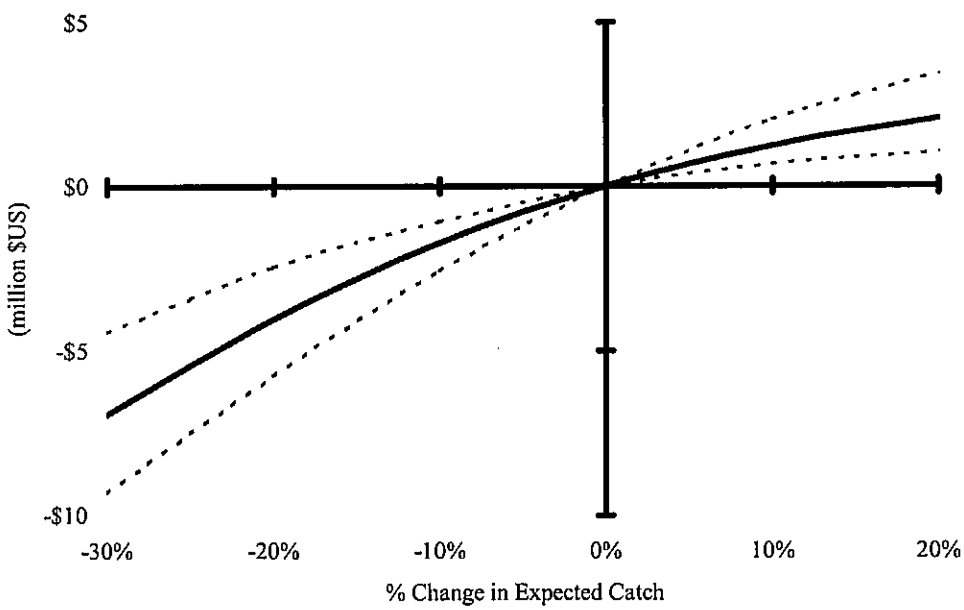


Fig. 3. Change in angler expenditures resulting from changes in the expected sportfishing catches. (90% confidence intervals are represented with *dotted* lines)

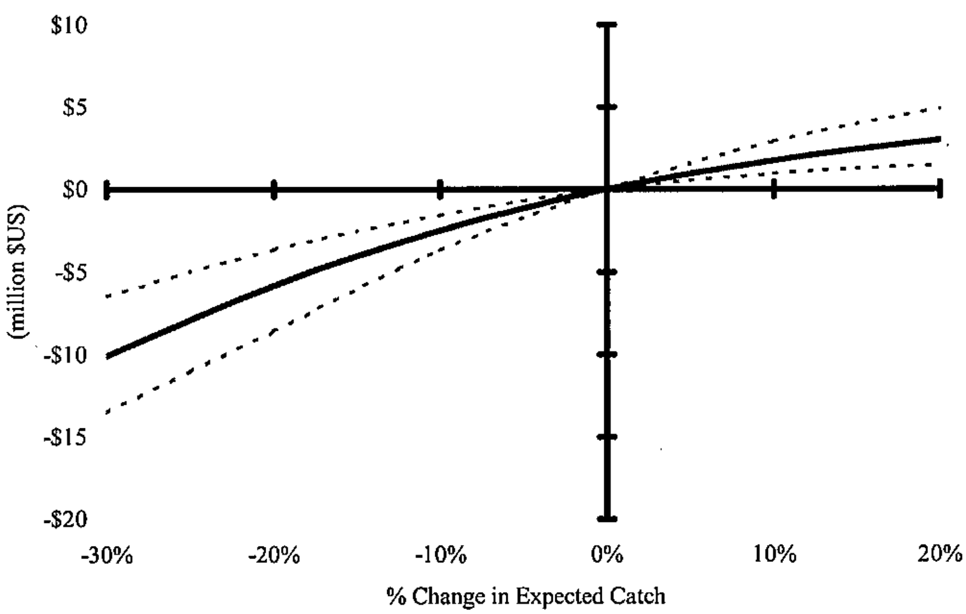


Fig. 4. Change in industry output resulting from changes in the expected sportfishing catches. (90% confidence intervals are represented with *dotted* lines)

4. Conclusions

The regional economic impact of recreational activities depends on the number of participants and their expenditure patterns. Variations in the number of participants arise from changes in the demand for recreational activity and are, in part, due to alterations in expected trip attributes. Consequently,

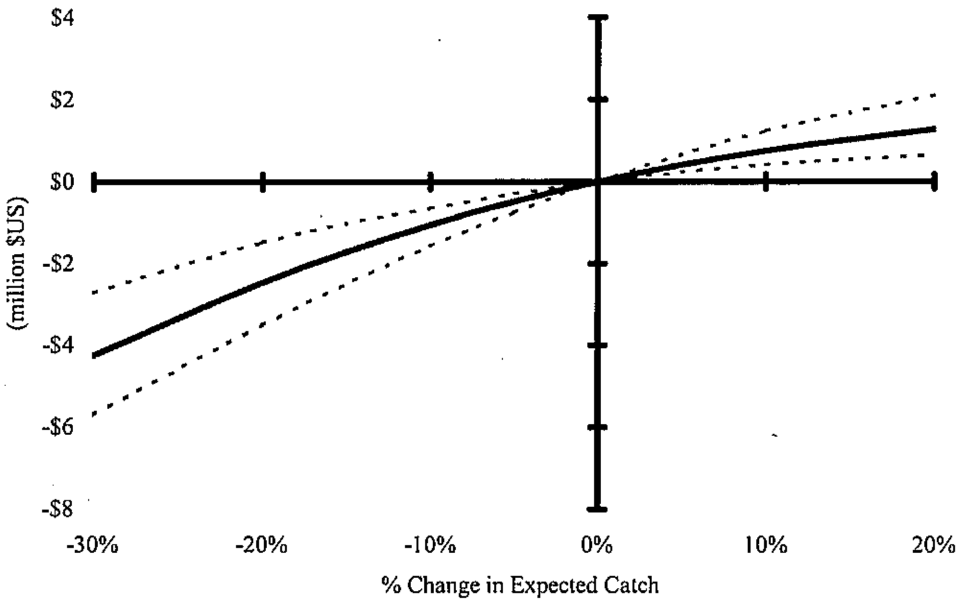


Fig. 5. Change in personal income resulting from changes in the expected sportfishing catches. (90% confidence intervals are represented with *dotted* lines)

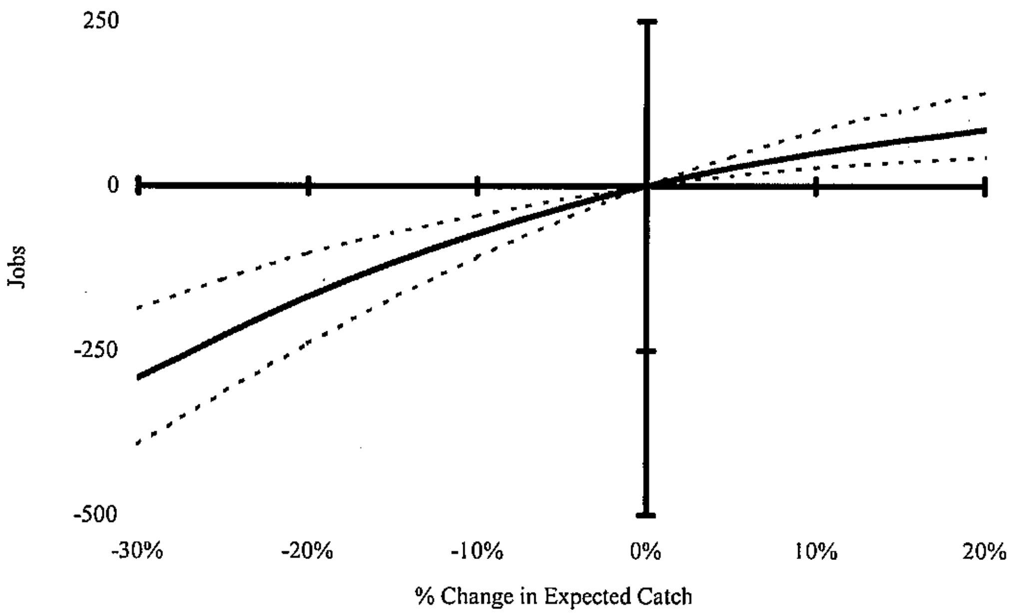


Fig. 6. Change in employment resulting from changes in the expected sportfishing catches. (90% confidence intervals are represented with *dotted* lines)

modifications of trip attributes alter the probability that the mean recreationist will take a given trip, change the expected number of participants, and affect regional economic activity. The advantage of formally linking a behaviorally based model of the demand for recreation with a regional economic model is that so doing allows a direct evaluation of the economic impact of predictable or controllable changes in trip attributes.

This approach is demonstrated in an application to the Lower and Central Cook Inlet saltwater sport fisheries for Pacific halibut and salmon. In the application, an econometric model of the determinants of individual participation decisions is linked to a simulation procedure to aggregate across individual decisions and estimate total sportfishing effort, and a regional input-output model that describes primary and secondary expenditure patterns. Altered spending behavior is driven by changes in participation, which are determined by changes in trip attributes (e.g., fish catch and size, and trip cost). The expenditures are summed and multiplied by the response coefficients to generate estimates of the economic impact of regulatory or environmentally induced changes in fishing trip attributes. The participation model is stochastic and allows for non-constant marginal utility; consequently primary and secondary impacts exhibit nonlinear responses to variations in trip attributes. In addition to being consistent with the theory of declining marginal utility, the nonlinear response of participation to changes in catch has practical relevance: a linear model would over-predict the increase in angler effort associated with an increase in catch or fish size and under-predict the reduction in angler effort that would result from a decrease in catch or fish size. Moreover, because the model is stochastic, confidence bounds can be estimated for changes in participation rates and associated changes in regional expenditures. The software module used to calculate changes in economic activity allows users to simulate changes in expected fish catch, size, and trip costs and to isolate these effects to the economic activities of specified fishery modes (charter, private, shore).

A baseline, reflecting the 1997 mean trip, is reported along with five sample levels of changes in expected catch rates. Such variations in catch could result from natural fluctuations in abundance, changes in allocation between commercial, subsistence, and sport fishers, changes in bag and possession limits, or environmental damage resulting from, for example, minerals exploration, development, production, or transportation activities.

In any large-scale economic study, there is a tradeoff between economic realism and cost in terms of money and time. This analysis is one of the most complex attempted for valuation of a sport fishery. However, every study is limited by explicit and implicit economic assumptions and data limitations. In this study, where there was plenty of theoretical work but very little precedence for applied analysis, much of the applied work was new territory. Looking back over the project some things worked out very well and others could have been improved. For the future, one area that needs further addressing is that in the participation model, when estimating the changes in the probability that individual fishers would take a trip, given varying trip attributes, it is assumed that the price of the trip will remain constant. In other words, we assume that supply was perfectly elastic. While this assumption is reasonable for shore and private trips, it is probably incorrect for charter trips. To the extent that charter trips make up a sizeable portion of sportfishing effort, and to the extent that charter trips do not exhibit perfectly elastic supply curves, there may be price adjustment especially in the short-run. For example, charter operators might respond to a short-run change in expected catches by lowering their prices and keeping their customer base rather than holding prices constant and losing customers as assumed in our model. While our assumption is valid in the long run, it may be less accurate in the short run.

References

Aas O (1995) Constraints on sportfishing and effect of management actions to increase participation rates in fishing. North American Journal of Fisheries Management 15:631–638

Alaska Department of Fish and Game (ADF&G) (1998) Harvest, catch, and participation in Alaska Sport fisheries during 1997. Alaska Department of Fish and Game, Division of Sport Fisheries, 333 Raspberry Road, Anchorage, AK, Fishery Data Series No. 9825

BenAkiva M, Lerman SR (1985) Discrete choice analysis: theory and applications to travel demand. MIT Press, Cambridge, MA

Bushnell RC, Hyle M (1985) Computerized models for assessing the economic impact of recreation and tourism. In: Probst DB (ed) Assessing the economic impacts of recreation and tourism. Southeastern Forest Experiment Station, Asheville, SC

Butler JS, Moffitt R (1982) A computationally efficient quadrature procedure for the one-factor multinomial probit model. Econometrica 50:761–765

Cohen MJ (1993) Economic aspects of technology accidents: an evaluation of the Exxon Valdez oil spill on Southcentral Alaska. Ph.D. dissertation, University of Pennsylvania

Coughenower DD (1986) Homer, Alaska guided sport fishing industry study. Marine Advisory Bulletin No. 22, Alaska Sea Grant College Program, University of Alaska, Fairbanks AK

Criddle KR (1994) Economics of resource use: a bioeconomic analysis of the Pacific halibut fishery. In: Proceedings of the Fourth International Symposium of the Conference of Asian and Pan-Pacific University Presidents, Alaska Sea Grant, Anchorage AK

Crutchfield JA, Zellner A (1962) Economic aspects of the Pacific halibut fishery. Fishery Industrial Research 1:1–173

Geier H, Holland D (1991) Economic aspects of federal livestock grazing policy: a regional economic analysis for the Okanogan-Ferry Area in Washington. Department of Agricultural Economics Staff Paper AE913, Washington State University, Pullman, WA

Geier H, Holland D, Schuster E (1994) Using IMPLAN to analyze small county economies for identification of development opportunities. United States Department of Agriculture, Forest Service Intermountain Research Station

Gillen WJ, Guccione A (1990) Disaggregating input-output models; an alternative to Wolsky's method. Economic Systems Research 2:39–42

Hamel C, Herrmann M, Lee ST, Criddle KR (2001) An economic assessment of Lower Cook Inlet sport fisheries: software program and manual. University of Alaska Fairbanks Coastal Marine Institute, Fairbanks, AK

Herrick Jr SF, Strand I, Squires D, Miller M, Lipton D, Walden J, Freese S (1994) Application of cost-benefit analysis to fisheries allocation decisions: the case of Alaska walleye pollock and Pacific cod. North American Journal of Fisheries Management 14:726–741

Herrmann M (1993) Using an international econometric model to forecast Alaska salmon revenues. Marine Resource Economics 8:249–271

Herrmann M (1994) The Alaska salmon fishery: an industry in economic turmoil. Journal of Aquatic Food Product Technology 3:5–22

Herrmann M (1996) Estimating the induced price increase for Canadian Pacific halibut with the introduction of the individual vessel quota program. Canadian Journal of Agricultural Economics 44:151–164

Herrmann M (2000) The individual vessel quota price induced effects for Canadian Pacific halibut: before and after Alaska IFQs. Canadian Journal of Agricultural Economics 48:195–209

Herrmann M, Greenberg JA (1994) A revenue analysis of the Alaska pink salmon fishery. North American Journal of Fisheries Management 14:537–549

Herrmann M, Lee ST, Hamel C, Criddle KR, Geier HT, Greenberg JA, Lewis CE (2001a) An economic assessment of the sport fisheries for halibut, chinook and coho salmon in Lower Cook Inlet: final report. University of Alaska Fairbanks Coastal Marine Institute, Fairbanks, AK

Herrmann M, Lee ST, Criddle KR, Hamel C (2001b) A survey of participants in the Lower and Central Cook Inlet halibut and salmon sport fisheries. Alaska Fishery Research Bulletin 8:107–117

Holland SM, Ditton RB (1992) Fishing trip satisfaction: a typology of anglers. North American Journal of Fisheries Management 12:28–33

Homans FR (1993) Modeling regulated open access resource use. Doctoral dissertation, University of California, Davis, CA

Jensen Consulting (1997) North Pacific Fishery Management Council recreational economic impact model. Reference manual for version 3.0

Jones and Stokes Associates Inc (1987) Southcentral sport fishing economic study. Alaska Department of Fish and Game, Division of Sport Fisheries, 333 Raspberry Road, Anchorage, AK

Krinsky I, Robb AL (1986) On approximating the statistical properties of elasticities. Review of Economics and Statistics 9:715–719

Lin B-H, Richards HS, Terry JM (1988) An analysis of the exvessel demand for Pacific halibut. Marine Resource Economics 4:305–314

Minerals Management Service (MMS) (1995) Final environmental impact statement for Cook Inlet planning area oil and gas lease sale 149. OCS/EIS/EA 95-0066, U.S. Minerals Management Service, Anchorage, AK

Natcher WC (1996) Economic Evaluation of superexclusive designation for the summer Norton Sound red king crab fishery. Masters Thesis, University of Alaska, Fairbanks, AK

National Research Council (NRC) Committee to Review Individual Fishing Quotas (1999) Sharing the fish: toward a national policy on individual fishing quotas. National Research Council, National Academy Press

North Pacific Fishery Management Council (NPFMC) (1991) Revised supplement to the draft supplemental environmental impact statement and regulatory impact review/initial regulatory flexibility analysis to the groundfish fishery management plans for the Gulf of Alaska and the Bering Sea/Aleutian Islands: longline and pot gear sablefish management in the Gulf of Alaska and the Bering Sea/Aleutian Islands. North Pacific Fishery Management Council, Anchorage, AK

North Pacific Fishery Management Council (NPFMC) (1997) Draft environmental assessment/regulatory impact review/initial regulatory flexibility analysis for proposed regulatory amendments to implement management alternatives for the guided sport fishery for halibut off Alaska. North Pacific Fishery Management Council, Anchorage, AK

North Pacific Fishery Management Council (NPFMC) (2000) Draft environmental assessment/regulatory impact review/initial regulatory flexibility analysis for a regulatory amendment to implement management measures under a guideline harvest level and/or moratorium for halibut in areas 2C and 3A. North Pacific Fishery Management Council, Anchorage, AK

Northern Economics (1990) Economic impacts of the S.S. Glacier Bay oil spill. U.S. Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage, AK

Olson D, Lindall S (1997) IMPLAN professional software, analysis, and data guide. Minnesota IMPLAN Group, Stillwater, MN

Steinback SR (1999) Regional economic impact assessments of recreational fisheries: an application of the IMPLAN modeling system to marine party and charter boat fishing in Maine. North American Journal of Fisheries Management 19:725–736

Summers P, Birss H (1991) Revitalizing the timber dependent regions of Washington: Report for the Washington Department of Trade and Economic Development. Northwest Policy Center, University of Washington Graduate School of Public Affairs, Seattle, WA

Thunberg E, Steinback SR, Gray G, Gautam A, Osborn M (1999) Summary report of methods and descriptive statistics for the 1994 Northeast Region marine recreational fishing participation survey. NOAA Technical Memorandum NMFSF/SPO39

Wolsky AM (1984) Disaggregating input-output models. The Review of Economics and Statistics 66:283–291

Marine Resource Economics, Volume 18, pp. 291–312
Printed in the U.S.A. All rights reserved

0738-1360/00 $3.00 + .00

Participation Decisions, Angler Welfare, and the Regional Economic Impact of Sportfishing

KEITH R. CRIDDLE
Utah State University

MARK HERRMANN
University of Alaska

S. TODD LEE
National Marine Fisheries Service

CHARLES HAMEL
University of Alaska

Abstract *We link a stochastic binary choice model of individual decisions to participate in the marine sport fisheries in Cook Inlet, Alaska, with a simulation-based sample enumeration procedure for aggregating estimates of individual angler welfare and a regionally adjusted zip code-level input-output model of regional economic activity. The result is a behaviorally based model for predicting changes in angler welfare and regional economic activity occasioned by changes in the demand for sportfishing that arise from changes in trip costs or the expected number, size, or mix of species caught. The advantages of this approach are that: changes in angler participation are determined by variables that are observable, predictable, or subject to management control; participation reflects declining marginal utility, and substitution and complementary effects across trip attributes; estimates of changes in aggregate angler welfare and changes in regional economic impacts are derived from changes in individual participation probabilities.*

Key words Recreational demand, angler welfare, regional economic impacts.

JEL Classification Codes Q22, Q26, R12, C25, C67.

Introduction

The marine sport fisheries of Lower and Central Cook Inlet, Alaska, support a large, recreation-based economic sector that provides non-pecuniary benefits to participants and income and net revenues to residents and businesses of the Kenai

---

Keith R. Criddle is a professor in the Department of Economics at Utah State University, Logan, UT 84322-3530, email: kcriddle@econ.usu.edu. Mark Herrmann is a professor in the Department of Economics at the University of Alaska Fairbanks, Fairbanks, AK 99775-6080, email: ffmlh@uaf.edu. S. Todd Lee is an industry economist at NOAA Fisheries, Northwest Fisheries Sciences Center, National Marine Fisheries Service, 2725 Montlake Blvd., E. Seattle, WA 98112-2097, email: Todd.Lee@noaa.gov. Charles Hamel is a research associate in the Department of Economics at the University of Alaska Fairbanks, Fairbanks, AK 99775-6080, email: ffcdh1@uaf.edu.

Partial funding for this project was provided by the University of Alaska Sea Grant College Program project 98-403 R14-17 and from the Mineral Management Service through the University of Alaska Coastal Marine Institute project 12-35-0001-30661 task order 14196. The views expressed herein are those of the authors and do not necessarily reflect those of their respective employers or the funding entities.

Peninsula region. Although the primary focus of this analysis is the fishery for Pacific halibut (*Hippoglossus stenolepis*), the region's most important saltwater sports fishery, the marine sport fisheries for chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon are treated as potential substitutes and complements. These fisheries are subject to intrinsic and fishery-induced variations in abundance and are managed under overlapping and evolving combinations of state and federal regulations and international agreements that affect the magnitude and allocation of sustainable harvests across commercial, subsistence, and recreational fisheries.

Pacific halibut are managed under the aegis of the Halibut Convention of 1923, an international treaty between the US and Canada. Under this agreement, the International Pacific Halibut Commission (IPHC) is responsible for establishing area-specific limits on the total direct and incidental harvest of Pacific halibut. The constant exploitation yield (CEY) management strategy used by the IPHC can be motivated as a strategy that maximizes the expected sustainable yield of halibut. Authority to apportion the CEY among competing commercial, sport, and subsistence interests is delegated to the individual nations. Allocations of the halibut CEY off Alaska are set by the US Secretary of Commerce based on recommendations of the North Pacific Fishery Management Council (Council).

Several current and potential policy issues highlight the importance of modeling changes in aggregate angler welfare and changes in regional economic impacts associated with recreational fisheries. For example, the *SS Glacier Bay* and *SS Exxon Valdez* oil spills occasioned a need for assessment of damages to commercial and recreational fisheries (Northern Economics 1990; Cohen 1993). Similarly, leasing of outer continental shelf minerals exploration and development rights requires an economic impact analysis that describes the likelihood that an oil spill could occur and how a spill would affect commercial and recreational catches, welfare, and regional economic activity (Herrmann, Lee, Hamel, and Criddle 2001). Another example is the allocation of catches between user groups. Historically, the Council has specified a commercial total allowable catch (TAC) for Pacific halibut as the regionally apportioned CEY less a bycatch allowance and expected non-commercial (sport and subsistence) catches. As the share of halibut caught by sport fishers has increased, commercial fishers have lobbied the Council to take actions to limit erosion of the commercial TAC. Growth of halibut sportfishing catches has been particularly pronounced in the Central Gulf of Alaska Region (Prince William Sound, Resurrection Bay, Kodiak, Yakutat, and especially Cook Inlet and adjacent portions of the Gulf of Alaska), where landings have increased from less than 2% of the CEY in the late 1970s to over 18% of the CEY before the end of the 1990s. During the same period, the number of Alaska resident sportfishing licenses sold increased 41% (from about 122,000 to 172,000 per year) and nonresident license sales increased 480% (from about 56,000 to 269,000 per year). In response to the increasingly acrimonious allocation conflicts between commercial and sport interests, the Council recently approved a guideline harvest level (GHL)—a flexible cap for charterboat-based sportfishing catches of halibut. The initial GHL was set equal to the 1995–99 average catch with provisions for adjustments in response to changes in halibut biomass (NPFMC 2000). Under the GHL, expected subsistence harvests and expected harvests by sport fishers who do not hire charterboat services continue to be deducted from the CEY and thus from the commercial TAC. If approved by the Secretary of Commerce, the GHL will be implemented in 2003. The GHL is regarded as a stopgap measure because there is little confidence that traditional sport fishery management measures can hold catches to no more than the GHL. To address these concerns, the Council approved the establishment of an individual fishing quota (IFQ) program for charter-based sportfishing catches of halibut (NPFMC 2001). Under the IFQ program, voluntary market transactions will allocate halibut within the charterboat sector and between commercial and charter operations. Subject to approval by the Secretary of Commerce, the charter IFQ program will replace the GHL. Cost-benefit analyses of these policy alternatives require an understanding of how the alternatives would affect angler participation rates, angler welfare, and regional economic activity.

There are two components to a comprehensive evaluation of the economics of marine sportfishing: estimation of the net benefits that accrue to sport fishers and assessment of the economic impact generated by marine sportfishing. We use a binary choice model of individual participation decisions to derive estimates of angler welfare and a regionally adjusted input-output model to estimate regional economic impacts.

The two most widely applied models for binary choice panel data are the fixed effects model (Chamberlain 1982) and the random effects model (Butler and Moffitt 1982). The fixed effects model accounts for heterogeneity by allowing individual-specific parametric shifts in the response function; thus it is appropriate for forecasting responses for those particular individuals. In contrast, the random effects model assumes that each individual's responses are correlated. Consequently, the random effects framework is more appropriate when the data are a random sample of individuals from a larger population of interest (Maddala 1987; Greene 1997). Moreover, the random effects model allows inclusion of variables that do not vary across trips (*e.g.*, socioeconomic variables), while the fixed effect model does not. A Monte Carlo experiment by Guilkey and Murphy (1993) has shown that use of the standard binomial probit model in cases where there is a random effect can bias the estimates of the parameters' standard errors. We use a random effects probit model of individual participation decisions and a Monte Carlo-based aggregation procedure to estimate changes in angler welfare conditioned on changes in sportfishing trip attributes. Many marine sport fishers contract with private charter operators for guide services. However, because the number of charter service providers is large and the barriers to entry are small, we assume that the charter sector can be characterized as perfectly competitive; thus charter operators earn normal profits. The economic impact of expenditures by anglers and charter operators is represented in a regional input-output model of the Kenai Peninsula region. We use a simulation model that links the participation rate, angler welfare, and regional economic impact models to estimate the changes in regional economic activity occasioned by environmental or regulatory changes.

Development of our model and presentation of the results is organized in three sections. We begin with a description of the data used to estimate model coefficients. In the second section, we describe the model framework and baseline parameter estimates. The third section integrates the participation-rate, angler welfare, and regional impact models in a set of simulations for various halibut catch levels and trip costs.

Description of Data

Three data sources were used to support our analyses: voluntary responses to two postal surveys and onsite interviews with Kenai Peninsula region local government officials and business community members.

UAF Angler Survey

The University of Alaska Fairbanks (UAF) angler survey (Lee *et al.* 1998; Herrmann, Lee, Criddle, and Hamel 2001) was developed and administered following Dillman's Total Design Method (Dillman 1978). An initial draft of the survey was administered to a small sample of anglers intercepted in the cities of Homer and

Seward, Alaska. Respondent comments were used to guide the development of a revised draft survey which was pre-tested using verbal protocol analysis (Ericsson and Simon 1993)—one-on-one interviews of randomly selected potential survey recipients from Fairbanks and Anchorage. These interviews provided an opportunity to study angler attitudes and vocabulary, their decision-making processes, and their ability to answer the survey questions. Information from all pre-testing stages was used to improve the content and clarity of the survey instrument, questions, format, cover design, and cover letters. The survey was mailed to 4,000 anglers randomly drawn from a list of individuals who purchased an Alaskan sportfishing license in 1997. The initial survey mailing was followed by a reminder card. Non-respondents were sent a second copy of the survey 14 days after the initial survey mailing. The first two survey mailings and the reminder card were sent by first class mail. A third survey was sent by certified mail to those who did not respond within 14 days after the second survey mailing. All survey mailings included a cover letter motivating the survey and a prize entry card to increase the response rate. Survey recipients were informed that by returning the prize entry card, they would be entered into a drawing for their choice of either a one-day halibut sportfishing trip aboard a charter vessel based in Homer, Alaska, or $150. The cover letter noted that three prizes would be awarded based on a random drawing from the entry cards returned.[1] The overall response rate was 70.1% on the 3,767 delivered surveys. Of the 2,641 respondents, 352 took at least one salmon or halibut sportfishing trip in marine waters off the Kenai Peninsula during 1997.

Responses to the UAF angler survey provided baseline demographic information (household after tax income, household size, and respondent gender, age, and education level), information about expenditures incurred and attributes of recent sportfishing trips taken in Lower or Central Cook Inlet, and angler preferences regarding hypothetical trips. Information on expenditures included transportation (*e.g.*, vehicle rental fees, vehicle fuel expenditures, and airfare), food and lodging (*e.g.* grocery purchases, restaurant and bar expenses, hotel/motel room rentals, vacation rentals, campground fees, other lodging), and fishing expenditures (*e.g.*, guide and charter fees and tips, fishing gear purchased specifically for the trip, fish processing and packaging fees, fishing derby entry fees, boat fuel and lubricants, and moorage and haulout fees). Survey responses were used to develop the individual-level participation rate model and to parameterize a regional economic model.

Nonresidents spent an average of $294.21 per charter-based sportfishing day: $103.87 in transportation and living expenses and $190.34 in fishing expenses. Nonresident fishing expenditures were dominated by charter fees ($140.75) and fish handling/processing charges ($32.72). Alaska residents from outside the Kenai Peninsula Borough spent an average of $204.91 per charter-based sportfishing day. Locals (Kenai Peninsula Borough residents) averaged $167.47 in fishing expenditures per day of charter-based fishing. The average cost-per-day for charter-based sportfishing trips was 64% higher than the average for trips taken on private vessels. Overall angling effort was distributed: 40% charter; 46% private vessel; and 14% from shore. While charter-based effort accounted for only 25% of the angling effort by Alaskans, it accounted for 59% of the angling effort by nonresidents. When aggregated across charter vessel, private vessel, and shore-based fishing modes, the average saltwater fishing trip yielded catches of 1.71 halibut for Alaskans and 2.43 halibut for nonresidents. Anglers who participated in dedicated halibut charters averaged catches of 3.51 fish per angler-day. Most survey respondents who took a saltwater sport fishing trip to the Cook Inlet region during 1997 took only one trip.

---

[1] All three prize winners selected the cash award.

ADF&F Angler Survey

The annual Alaska Department of Fish and Game (ADF&G) angler survey was sent to 22,000 individuals in 1997 and yielded a response rate of 45.8% on delivered surveys after three mailings (Howe *et al.* 1998). Sportfishing effort in Lower and Central Cook Inlet during 1997 was estimated to total 197,556 angler-days. Participation by nonresidents accounted for 44% of total days fished (86,970 angler-days). In the more expensive charter fishery, nonresidents comprised 65% of the total charter effort, while comprising just 28% and 37% of the private vessel and shoreline fishing days, respectively. A Monte Carlo simulation procedure was used to combine the participation rate model and effort estimates from the ADF&G survey to form estimates of total angler participation and net benefits.

Onsite Interviews

Responses to the UAF angler survey were combined with State and Borough employment and earnings data and information gathered through onsite interviews with local government officials and business leaders. It was then used to update and groundtruth the technical coefficients of a regional input-output model of the Kenai Peninsula economy and to disaggregate the sportfishing sector (Herrmann, Lee, Hamel, and Criddle 2001; Herrmann, Lee, Criddle, and Hamel 2001).

Because marine sportfishing was not the sole or primary motivation for trips taken by some survey respondents, it would have been inappropriate to attribute all of the trip expenses to the existence of marine sportfishing opportunities.[2] Expenditure estimates were, therefore, adjusted downwards using data on trip purpose from the survey (see Herrmann, Lee, Criddle, and Hamel 2001). The total spending directly attributable to the fishing component of trips taken in 1997 (*i.e.*, money that would not have been spent if the fishing component were cancelled) was estimated at $34.1 million, $28.5 million of which was spent on the Kenai. Because we assumed that local residents would substitute spending on other regional recreational activities (*e.g.*, freshwater sportfishing or marine sportfishing in Prince William Sound) for foregone marine sportfishing expenditures, their expenditures ($3.5 million) were also deducted. The $25.0 million remainder reflects an estimate of the infusion of spending on the Kenai Peninsula that would not have occurred in the absence of marine sportfishing opportunities in Lower and Central Cook Inlet (table 1). The adjusted 1997 expenditure data were used as a baseline in the regional economic model.

Model Framework and Baseline Estimates

Individual Participation Decisions

Changes in trip costs, expected catch rates, fishery regulations, and environmental quality affect the expected net benefit associated with sportfishing, and therefore the decision to participate in (take) a sportfishing trip. Previous studies (*e.g.*, Holland and Ditton 1992, Aas 1995, Thunberg *et al.* 1999) have used variation in demo-

---

[2] While the unadjusted values may be a better predictor of the level of expenditures attributable to the mix of participants in the fishery in a typical year, only expenditures by those whose trip destination decision was influenced by the existence of marine fishing opportunities can be viewed as being contingent on the existence and attributes of the marine sport fisheries.

Table 1
Kenai Peninsula Area Expenditures by Alaskans (Non-local) and Nonresidents that can be Directly Attributed to Lower and Central Cook Inlet Halibut or Salmon Sportfishing Trips

	Expenditures ($ million)	
	Fishing Expenditures	Other Expenditures
Auto fuel		2.208
Auto/RV rentals		0
Lodge		3.061
Groceries		2.443
Restaurant & bar		1.997
Charter	9.518	
Gear	1.659	
Processing	2.202	
Derby	0.171	
Boat fuel	1.279	
Haul/moorage	0.433	
Total	15.263	9.710

graphic characteristics to explain changes in the demand for recreational fishing. While such models may provide useful descriptions of past participation decisions, they are not useful for predicting future participation rates because the resulting forecasts are conditional on uncertain conjectures about demographic change. That is, such models shift the focus from forecasting changes in participation to predicting demographic change and are not suitable for predicting changes in the demand for recreational fishing that might arise in response to changes in trip costs, fishing conditions, or management actions. Our approach avoids these problems by focusing on explanatory variables that are predictable or subject to management control. For example, total catch levels are a management choice subject to population dynamics that are well characterized for halibut and conditionally predictable for salmon. In addition to being constrained by overall catch limits, catch levels are subject to management actions related to season length, bag, possession, and catch-and-release regulations. Similarly, charter trip costs are subject to management influence through the erection of barriers to entry (license limitation) and the direct effect of permit and license prices. Consequently, our model is better suited for policy evaluation and forecasting participation rate responses to changes in trip costs and catch rates.

In the UAF survey, respondents were presented a set of hypothetical fishing trips and asked to identify which trips they would take. Each hypothetical trip was described in terms of one of three cost levels ($100, $170, or $240 per day), one of four halibut keep and release levels (0, 2, 4, or 6 fish per trip), one of four average halibut weights (0, 20, 40, or 80 lbs. per fish), one of three chinook catch levels (0, 1, or 2 fish per trip), one of four average chinook weights (0, 15, 25, or 50 lbs. per fish), one of four coho catch levels (0, 2, 4, or 6 fish per trip), and one of two average coho weights (0 or 7 lbs. per fish). Attributes of the hypothetical trips were derived from historical mean catch and average weight data and pretest discussions with recreational fishers. The cost per day was identified as the sum of sportfishing related costs, such as tackle and bait purchased specifically for the trip, charter/guide fees, and trip specific transportation costs such as auto and boat fuel. For consistency, average catch (weight) was set to zero whenever average weight (catch) was zero. In order to estimate an indirect utility function that includes the main effects and all relevant two-way interactions, 27 trips were selected and assigned to nine distinct three-trip blocks. The 27 trips and their nine blocks were simultaneously selected based on a criterion that maximized the determinant of the information matrix. The resulting parsimonious experimental design allows for the efficient identification of substitution and complementary effects across attributes, and for the possibility of nonlinear marginal utility. While these types of effects are predicted in economic theory, they are seldom identified in empirical studies of actual trips because attributes are often highly collinear or lack sufficient variation. Each of the 4,000 survey recipients was randomly assigned one of the nine blocks of three hypothetical trips.

The participation decision was modeled as a nonlinear random utility function. The utility that individual i derives from trip t is given by:

$$u_{it} = f(x_{it}, z_i, \beta, \gamma) + e_{it},$$

where the vector, x_{it}, describes the attributes of the t-th trip taken by the i-th individual; socioeconomic and demographic variables for each individual are included in the vector z_i; β and γ are vectors of parameters associated with the fishing trip attributes and socioeconomic variables, respectively; and the errors, e_{it}, are normally distributed with an expected value of zero.

Respondents were asked whether they would take a trip, described by attributes x_{it}. Those who would take the trip obtain a utility level of u_{it}. Those who would not take the trip receive:

$$u_{i0} = f(0, z_i, \beta, \gamma) + e_{i0},$$

the utility level associated with not taking the trip, which is also the opportunity cost of taking the trip. Since the actual levels of utility are unobservable, the model is made operational by specifying a binary indicator y^* that denotes which choice was made; that is, $y^*_{it} = 1$ if the respondent would take trip and $y^*_{it} = 0$ otherwise. Assuming that individuals make rational choices, $y^*_{it} = 1$ implies that the expected utility of taking the trip is greater than the expected utility of not taking the trip; that is, $E(u_{it} \geq u_{i0})$. Conversely, $y^*_{it} = 0$ implies that $E(u_{it} < u_{i0})$.

We specified the random utility model as:

$$y^*_{it} = \alpha_0 + \alpha_1 P_t + w_t^T B w_t + n_t^T \Lambda n_t + z_i^T \Gamma \tag{1}$$

$$= \alpha_0 + \alpha_1 P_t + \begin{bmatrix} w_t^h \\ w_t^{ch} \\ w_t^{co} \\ \hline 0 \end{bmatrix}^T \left[\begin{array}{c|ccc} \beta_{11} & \beta_{12} & 0 & 0 \\ \beta_{21} & \beta_{22} & \beta_{23} & 0 \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \\ \hline 0 & 0 & 0 & 0 \end{array}\right] \begin{bmatrix} 1 \\ \hline w_t^h \\ w_t^{ch} \\ w_t^{co} \end{bmatrix}$$

$$+ \begin{bmatrix} n_t^h \\ 0 \\ 0 \\ \hline 0 \end{bmatrix}^T \left[\begin{array}{c|ccc} \lambda_{11} & \lambda_{12} & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 \end{array}\right] \begin{bmatrix} 1 \\ \hline n_t^h \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} sex_i \\ age_i \\ edu_i \end{bmatrix}^T \begin{bmatrix} \gamma_1 \\ \gamma_2 \\ \gamma_3 \end{bmatrix}$$

where the binary variable y_{it}^{*} was assigned a value of 1 when survey respondent i indicated a willingness to take trip t, and 0 otherwise. The variables P_t, n_t^s, and w_t^s are hypothetical attributes that denote the cost-per-day of taking trip t and the number and total weight (a product of the number of fish caught and average weight per fish) of species s caught on trip t, where halibut, chinook, and coho are denoted by the superscripts h, ch, and co, respectively. The variables sex_i, age_i, and edu_i are the gender, age, and education level reported by individual i. The superscript T is used to denote matrix transposition.

The data and coefficient matrices are partitioned to emphasize components responsible for linear and quadratic factors and to highlight the exclusion restrictions. Because the plausible catches for chinook were 0, 1, or 2 fish, the data lacked sufficient variation to estimate the linear, quadratic, and interaction terms that we considered to be important. The weight variable was not subject to this limitation because the hypothetical trips included total catch weights of 0, 15, 25, 30, 50, and 100 lbs. of chinook, enough variability to support the estimation of all of the linear and nonlinear direct and interaction terms of interest. Although we had ample variation in coho catches (0, 2, 4, 6), the invariance in coho weight (7 lbs. per fish for all hypothetical trips where coho were caught) would have caused the information matrix to be singular if we had included data representing both the weight and number of coho caught. We chose to exclude coho numbers in order to be able to estimate an interaction between coho and chinook, an interaction that focus groups suggested could be important. That is, because we lacked sufficient variation to specify a full set of interactions in Β and Λ, we chose a full specification for Β and a restricted specification for Λ.

The coefficient matrices α, Β, Λ, and Γ, and a random effects parameter, ρ, were estimated simultaneously for resident and nonresident respondents using a random effects probit procedure. To ensure that the participation decisions were grounded in recent experience, coefficient estimation was based on the 352 surveys returned by respondents who took at least one salmon or halibut sportfishing trip in marine waters off the Kenai Peninsula during 1997. Each respondent answered questions regarding three different hypothetical trips, yielding a total of 1,056 observations.

Coefficient estimates are reported in table 2. The random effect parameter, ρ, is statistically different from zero at the 99% level, confirming the presence of a random effect. The point estimates of the parameters accord well with economic theory: the price coefficient is negative; the coefficients on total halibut, chinook salmon, and coho salmon weights and halibut catches are positive; coefficients on the quadratic terms and cross products are negative, implying that recreational fishers experience decreasing marginal utility and that catches of each species are substitutes for catches of the others; and the probability of taking a trip increases as a function of income, age, and education, and is higher for males. With exception of the coefficient on squared halibut weight in the nonresident equation and the coefficient on squared coho weight in the Alaskan resident equation, all coefficients on price and linear, nonlinear, and cross-product terms for catch weight and numbers were significantly different from zero at the 5% level (table 2). Resident gender and nonresident education level were the only socioeconomic variables found to be statistically significant. Overall model performance was good: the log likelihood at convergence was –542.503 and –731.047 when the parameters were set to zero, and R^2 was 0.442.[3]

---

[3] The log-likelihood at convergence is the value of the log-likelihood function evaluated at the parameter values we report. These are the parameter values that maximize the log-likelihood function and were found by using a numerical optimization algorithm. Our estimate of R^2 follows Veall and Zimmermann (1996):

$$R^2 = \frac{(LL_m - LL_0)}{(LL_m - LL_0 + N)} \Big/ \frac{-2\, LL_0}{(N - 2\, LL_0)},$$

where LL_m is the value of the log-likelihood function from the model, LL_0 is the value of the log-likelihood function with all of the slope coefficients set at zero, and N is the total number of observations.

Table 2
Random Effects Probit Model Parameter Estimates

	Alaskans (local and non-local)		Nonresidents	
	Estimates	t-ratios	Estimates	t-ratios
Intercept	–2.7965	–3.01	–1.4818	–1.94
Price	–0.0124	–7.59*	–0.0094	–6.98*
Total weight of halibut	0.0373	3.28*	0.0229	2.54*
Total weight of chinook	0.1038	4.35*	0.0734	3.62*
Total weight of coho	0.1263	3.02*	0.1165	3.20*
Squared halibut weight	–0.0001	–2.91*	–0.0001	–1.34
Squared chinook weight	–0.0006	–3.44*	–0.0004	–2.59*
Squared coho weight	–0.0008	–1.18	–0.0011	–1.82*
Product of total weight of halibut and coho caught	–0.0005	–3.55*	–0.0004	–3.22*
Product of total weight of halibut and chinook caught	–0.0007	–2.92*	–0.0005	–2.41*
Product of total weight of chinook and coho caught	–0.0018	–3.62*	–0.0010	–2.30*
Number of halibut caught	1.1228	2.11*	0.9263	2.36*
Squared number of halibut caught	–0.1513	–2.25*	–0.1300	–2.56*
Gender (1=male)	0.4048	2.17*	0.0970	0.59
Age	0.0103	1.44	0.0003	0.05
Education (1=college graduate)	0.3394	1.79	0.3839	2.50*
ρ	0.1942	2.82*	0.1942	2.82*

* Significantly greater (less) than zero at $p \leq 0.05$ for one-sided tests on all variables except the socio-economic variables where two-sided tests were performed.

Although changes in resource abundance that arise from stock dynamics or changes in environmental conditions are not explicitly represented in the participation model, such changes affect the average weight and number of fish caught in the sport fishery, trip attributes that are explicitly represented in our model. This linkage is implicit in ADF&G's escapement-based management strategy for salmon and is explicit in the CEY management strategy for halibut. Although the management agencies (ADF&G for salmon and NPFMC for halibut) are not required to distribute changes in the salmon guideline harvest level or halibut CEY proportionally among commercial, sport, and other fisheries, the history of management actions in the salmon fishery is consistent with this assumption. In addition, subject to approval of the Secretary of Commerce, recent Council action (NPFMC 2001) explicitly specifies a proportionality principle for accommodation of changes in the halibut CEY.

Total Demand and Angler Welfare

The conditional individual participation probabilities were aggregated into estimates of total demand using a simulation-based sample enumeration method that takes into account differences in demographic characteristics and variability in the number of days fished per year. The sample enumeration method, described in BenAkiva and Lerman (1985), takes into account differences in socioeconomic characteristics and variability in the number of days fished per year by developing forecasts for each individual in the sample. We use this information to weight the simulations by the number of days fished. The simulation provides separate results for Alaskan residents and nonresidents. The general formula for all forecasts is:

$$\%\Delta Y = \frac{\sum_{i=1}^{n} \Phi(\hat{u}_{i,1})\, days_i - \sum_{i=1}^{n} \Phi(\hat{u}_{i,0})\, days_i}{\sum_{i=1}^{n} \Phi(\hat{u}_{i,0})\, days_i}, \tag{2}$$

where $\%\Delta Y$ is the percentage change in total participation occasioned by a change in trip attributes. The indirect utility that individual i derives from a trip with baseline attributes is denoted $\hat{u}_{i,0}$. In contrast, $\hat{u}_{i,1}$ denotes the indirect utility obtained from a fishing trip with attribute levels that reflect an α percent change from the baseline levels. The number of days fished by individual i in marine waters off the Kenai Peninsula during 1997 is represented by $days_i$. The notation $\Phi(\cdot)$ represents the cumulative normal distribution function. Because point estimates of percentage changes in the number of angler-days are highly nonlinear, confidence intervals were based on 10,000 draws of a Monte Carlo procedure described in Krinsky and Robb (1986).

Following Hanemann (1999), conditional estimates of angler welfare were calculated from the estimated participation rate model as the product of the weighted average compensating variation[4] per trip taken and the total number of angler-days spent fishing for salmon and halibut in Lower or Central Cook Inlet. The expected maximum utility that individual i derives from trip j can be represented by $M_{i,j} = E[\max(u_{i,1}, u_{i,0})]$, where $u_{i,1} = v_{i,1} + e_{i,1}$ denotes the utility received from taking a fishing trip and $u_{i,0} = v_{i,0} + e_{i,0}$ denotes the utility received from not taking a fishing trip. The economic welfare associated with the choice is $cv_{i,j} = -M_{i,j}/\pi_p$, where $cv_{i,j}$ is the compensating variation that individual i derives from trip j with corresponding attributes, and π_p is the marginal utility of income and is equal to the coefficient estimate on the price (cost of trip) variable. Since the marginal utility of income is held constant in our model, this welfare measure is also the equivalent variation welfare measure.

The value of $M_{i,j}$ can be calculated from the probability density function:

$$M_{i,j} = \int_{-\infty}^{+\infty}\int_{-\infty}^{v_0+e_0-v_1} (v_{i,0} + e_{i,0})\phi(e_{i,0}, e_{i,1})\partial e_{i,1}\partial e_{i,0} + \int_{-\infty}^{+\infty}\int_{-\infty}^{v_1+e_1-v_0} (v_{i,1} + e_{i,1})\phi(e_{i,0}, e_{i,1})\partial e_{i,0}\partial e_{i,1},$$

where $\phi(\cdot)$ is the bivariate normal probability density function. If the utility of not taking a trip is normalized such that $u_{i,0} = 0$, then a trip will only be taken when $v_{i,1} + e_{i,1} \geq 0$, and M simplifies to:

$$M = \int_{-v_1}^{+\infty} (v_{i,1} + e_{i,1})\phi(e_{i,1})\partial e_{i,1} = v_{i,1}\Phi(v_{i,1}) + \phi(v_{i,1}).$$

---

[4] Compensating variation is a measure of net benefit to consumers. It can be motivated as an additional cost that, if added to the cost of a particular sportfishing trip, would leave the sport fisher indifferent between taking and not taking the trip.

The estimated weighted average compensating variation across all individuals for trip j with corresponding attributes is:

$$\hat{cv}_j = \frac{\sum_{i=1}^{n}\left[\hat{cv}_{ij}\ days_{ij}\Phi(\hat{u}_{ij})\right]}{\sum_{i=1}^{n}\left[days_{ij}\Phi(\hat{u}_{ij})\right]}, \tag{3}$$

where $days_{ij}$ is the number of angler days fished by angler i during 1997 in the Lower and Central Cook Inlet salmon and halibut sport fisheries (Howe *et al.* 1998).

The estimated total compensating variation for trip j with corresponding attributes is:

$$CV_j = \hat{cv}_j\ Days_j(1 + \%\Delta Y), \tag{4}$$

where $Days_j$ is the total number of angler-days fished for salmon and halibut in Lower or Central Cook Inlet by all individuals, and $\%\Delta Y$ is the change in participation relative to the baseline 1997 season.

Changes in compensating variations will then be calculated as:

$$\Delta CV = CV_j - CV_k, \tag{5}$$

where CV_j is the compensating variation associated with trips with attributes j, and CV_k is the compensating variation associated with trips with attributes k.

The estimated average daily compensating variation for fishing trips in 1997 was \$82.51 for Alaskans and \$118.88 for nonresidents (table 3). The corresponding estimate of total compensating variation was \$19.46 million (\$10.34 million for nonresidents and \$9.12 million for residents). Every change that affects sportfishing trip attributes affects the average sport fisher's decision to participate, regardless of whether the attribute change is due to changes in the cost of a sportfishing trip, natural population fluctuations, regulatory change, or environmental damage. Changes in the probability of individual participation lead to shifts in the total demand for sportfishing trips and changes in angler welfare.

Table 3
Estimated Compensating Variation

Residency Category	Angler Days	CV per Day ($) Mean	CV per Day ($) 90% Lower Bound	CV per Day ($) 90% Upper Bound	Total CV ($ million) Mean
Local	48,877	82.51	47.44	123.89	4.032
Alaskan	61,709	82.51	47.44	123.89	5.091
Nonresident	86,970	118.88	85.20	155.95	10.339
Total	197,556				19.463

Regional Impact Analysis

Marine sportfishing can take place from shore, private or rented boats, or charter boats. The expenditures associated with each of these choices contribute to regional economic activity; thus changes in participation that arise from changes in trip attributes affect regional economic activity. Impact analysis focuses on the direct, indirect, and induced effects that changes in expenditures have on output (production), income, and employment. Direct effects are changes associated with immediate changes in final demand. Indirect effects are changes associated with changes in the demand for inputs to the production process. Induced effects result from changes in household spending patterns that arise from changes in household income as a consequence of the direct and indirect effects.

The Magnuson-Stevens Fisheries Conservation and Management Act (US Department of Commerce 1996) places importance on both efficiency and equity issues when managing the nation's fisheries. While economic efficiency (*i.e.*, consumer surplus for anglers and producer surplus for charter operators) is a standard objective identified by economists, recent litigation involving fisheries has stressed distributional issues in addition to efficiency considerations (*e.g.*, Northern Economics 1990; Marine Advisory Program 1992; Cohen 1993). Economic impact analysis provides a snapshot of the economic interdependencies of various industries in a regional economy, and therefore allows analysts to model the downstream effects of demand changes for commodities or services. Because opportunity costs and willingness to pay do not enter into the impact assessment framework, the results of an economic impact analysis should not be confused with statements of value. It should be noted, however, that the results that yield the greatest value under a net benefit analysis could imply very disproportional allocations among stakeholders. Although notions of fairness and equity do not enter into the standard net benefits framework, economic impact analyses are useful tools for tracking and identifying impacts of alternative policies on revenue, income, and employment. For a more detailed discussion on the differences and appropriate uses of cost-benefit and economic impact analyses in fisheries, see for example, Edwards (1994) or Steinback (1999).

Development of the regional economic model is detailed in Herrmann, Lee, Hamel, and Criddle (2001) and Hamel *et al.* (2002); a brief summary is included here for convenience of the reader. We used IMPLAN (Olson and Lindall 1997) as the foundation of a zip-code level economic model of the Kenai Peninsula. Although the technical coefficients used by IMPLAN are regularly updated, regions such as Alaska, where the small numbers of firms creates disclosure problems, and where the economy is rapidly evolving, are not well characterized by the technical coefficients included in the IMPLAN database. To address this problem, we used State and Borough employment and earnings data, information reported in NPFMC (2000), and information gathered during two weeks of onsite interviews with local government officials and business leaders in Kenai Peninsula Borough communities. Individuals interviewed and specific changes to the IMPLAN technical coefficients are identified in Herrmann, Lee, Hamel, and Criddle (2001).

Although IMPLAN represents 528 economic sectors, sectors that are regionally important but small relative to other sectors in the national economy are often subsumed in general categories. For example, IMPLAN's amusement and recreation sector includes sportfishing and 105 other types of recreation. In order to highlight the regional economic impacts of changes in sportfishing participation levels, it was necessary to disaggregate marine sportfishing from the amusement and recreation sector. We followed a disaggregation procedure for the sportfishing sector suggested in Steinback (1999), which involved constructing additional sectors within the

IMPLAN framework and reprogramming the corresponding social accounting matrices to reflect the characteristics of the disaggregated subsector. This choice was driven by our interest in examining changes in final demand that might arise from incremental changes in predictable or controllable trip attributes. If we had wanted to measure the effects of a complete shutdown of the charter fishery to simulate, for example the result of a catastrophic oil spill, the supply side approach used in Leung and Pooley (2001) might have been more appropriate. However, because forward linkages from the charter sector to other industry sectors on the Kenai Peninsula are negligible (the guided sport fishery is fueled almost exclusively by angler demand), and given an absence of intra-sectoral sales, multipliers derived from a hypothetical extraction method would not have likely affected impacts of a significantly greater scale than those from a traditional demand shock. For a detailed accounting of the individual expense categories, corresponding Standard Industrial Classification codes and translation to the IMPLAN sectoral scheme, the reader is referred to Herrmann, Lee, Hamel, and Criddle (2001).

Individual sportfishing activities are accommodated differently from direct income-generating activities, such as guiding. We account for individual sportfishing activities by identifying their expenditure patterns in retail and service sectors; that is, by treating visiting anglers as "cost centers" for various goods and services rather than as an identifiable economic sector (Jensen Consulting 1997). We allocate recreational expenditures among these sectors, using angler expenditure data gleaned from the UAF angler survey (Herrmann, Lee, Criddle, and Hamel 2001). Finally, impact scenarios were run in IMPLAN to generate corresponding response coefficients for each of the retail service sectors frequented by anglers. These response coefficients and those developed for the charter sector were linked in a stand-alone recreational module (Hamel *et al.* 2001).

Simulation Results and Analysis

The simulation model integrates the participation-rate, angler welfare, and regional economic impact models and can be used to explore the effects of changes in trip costs and expected catches on angler-days fished, angler welfare, and regional economic activity.[5] The model was developed, in part, to meet the needs of environmental and regulatory impact analyses related to outer continental shelf minerals exploration, development, and production activities in the Cook Inlet Planning Area (Herrmann, Lee, Hamel, and Criddle 2001). However, preliminary model results have also been used in regulatory analyses related to recent management actions designed to constrain the expansion of charter-based sportfishing for halibut (NPFMC 2000) and analyses related to the adoption of individual fishing quotas for charter-based halibut catches (NPFMC 2001).

---

[5] Due to space constraints, it is not possible to report all the details that went into the modeling and simulation analysis. Because of this, we offer the reader the following products that can be obtained by contacting the authors.

- The simulation program <$FISH.XLS> can be downloaded as a compressed file, extracted, and run in Microsoft Excel.
- The manual to <$FISH.XLS> (Hamel *et al.* 2001) is available as an Adobe Acrobat (pdf) file.
- The final project report to Minerals Management Service-University of Alaska Coastal Marine Institute (Herrmann, Lee, Hamel, and Criddle 2001) is available as an Adobe Acrobat (pdf) file. This file also includes the software manual to run $FISH.XLS.
- The survey data and methods are more fully explained in a final report to Alaska Sea Grant, Lee *et al.* (1998), available as an Adobe Acrobat (pdf) file.

Changes in the probability that the average sport fisher will take a trip are calculated using the parameters estimated from the probit model and aggregated into predictions of changes in total sportfishing effort. They are then used to predict changes in angler welfare and regional economic impacts. Figure 1 depicts changes in the magnitude of sportfishing effort as a function of changes in the expected catch of halibut.[6] For example, a 30% reduction in expected catch-per-day is predicted to lead to a 25.1% reduction in angler participation, while a 30% increase would be expected to increase total angler-days fished by 11.0%. Because the estimated participation model is nonlinear and convex, successively larger increases in the expected catch of halibut lead to successively smaller incremental increases in the number of angler-days fished. That is, changes in participation show a declining marginal utility of catch and that Alaskans are more sensitive than nonresidents to changes in expected catch.

Reductions (increases) in expected catch reduce (increase) the compensating variation in two ways. First, the marginal sport fisher will drop out (enter) of the fishery as the expected benefits (in terms of catch) decrease (increase), thereby decreasing (increasing) the total net benefits of the fishery. Second, the net benefit of taking a trip is also reduced (increased) for all the sport fishers who continue to participate because each trip produces less (more) net benefit when the catch rate declines (increases). These changes are represented in figure 2. For example, a 30% reduction in expected catch is predicted to lead to a 56.7% reduction in total compensating variation. Conversely, changes in halibut abundance or management

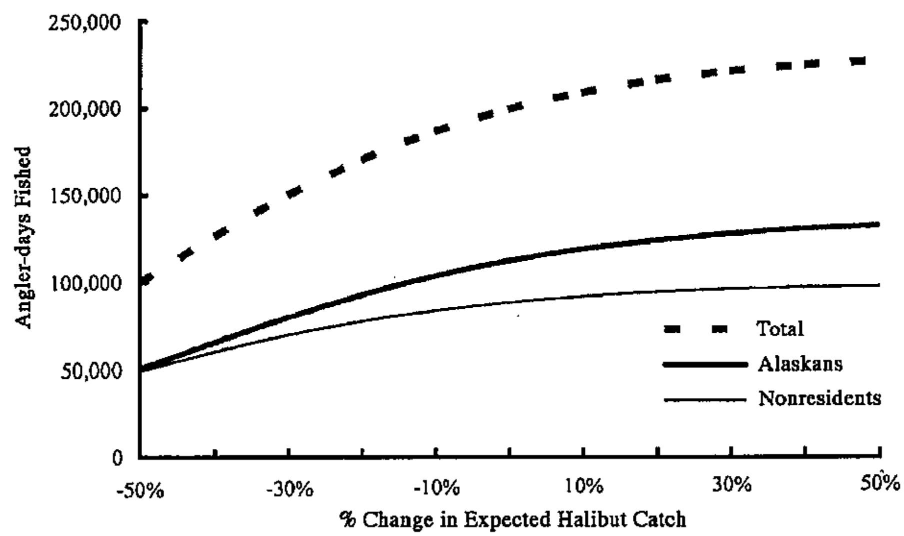


Figure 1. The Effect of Changes of Expected Halibut Catch on Angler Participation

[6] Changes in fishery regulations or environmental changes that affect fishery biomass can be expected to change the total weight of harvested fish through both fish numbers and average weight of the fish. In this manuscript, we hold the average weight of fish constant and focus our analysis on changes to expected catch, which is likely to be the dominant change to total weight from regulatory or environmental changes.

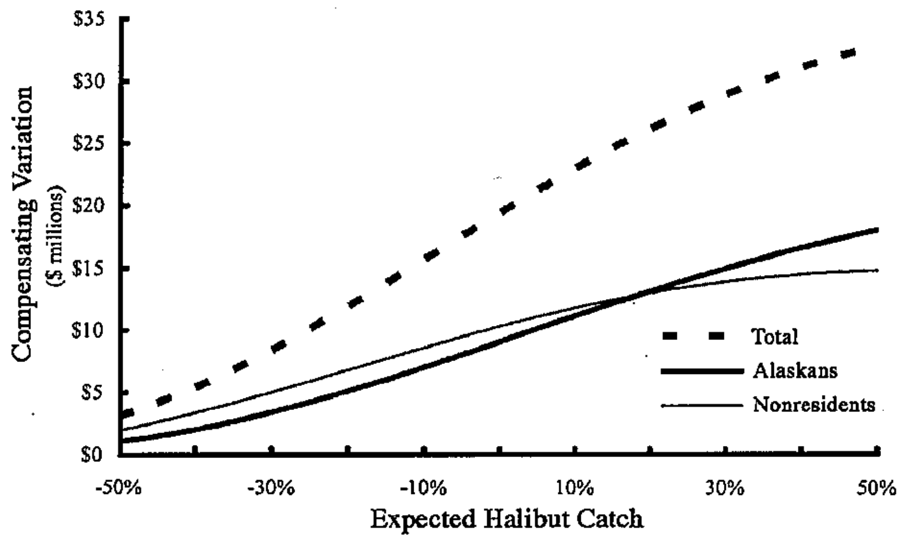


Figure 2. The Effect of Changes in Expected Halibut Catch on the Magnitude of Total Compensating Variation

policies that increase expected halibut catch-per-day by 30% could be expected to increase angler net benefits by $5.8 million for residents and $3.6 million for nonresidents, a 48.4% increase in total angler welfare. Note that the total net benefits that accrue to Alaskan anglers are more responsive to changes in expected catch than are those obtained by nonresidents.

Unlike angler net benefits, which are a measure of economic efficiency, impact analysis is a measure of distribution. That is, changes in average daily compensating variation affect regional economic activity when they lead to changes in the total number of sportfishing days. Furthermore, the net regional impact is limited to those recreators who do not substitute other types of expenditures on the Kenai Peninsula in lieu of expenditures that they would have made if they had gone fishing. Assessment of the regional economic impacts of marine sportfishing on the Kenai Peninsula Borough begins with a baseline of expenditures that fluctuates as sport fisher behavior responds to changes in fishing conditions. Table 1 breaks out the $25 million of "new" money to the region spent by non-local Alaskans and nonresidents ($15.3 million of fishing related expenses and $9.7 million of other expenses). Changes in expected angler success (catch) affect participation decisions and, consequently, angler expenditures, industry output, personal income, and employment. The magnitudes of these effects are reported in table 4. The results indicate, for example, that for a 10% decrease in expected halibut catches, net benefits to resident and nonresident sport fishers will decrease by $3.7 million (19.2%). The regional impacts include a $2.0 million (7.1%) decrease in marine sport fishing related direct, indirect, and induced output expenditures in the Kenai Peninsula region, which will result in a decrease of $0.9 million (7.1%) in personal income and a loss of 59 jobs related to the marine sport fishery. For a 10% increase in expected halibut catch-per-day, net benefits to sport fishers will increase by 18.1%, and there will be a 5.3% increase in direct, indirect, and induced output expenditures in the Kenai

Peninsula region, which will result in a 5.3% increase in personal income and a 5.2% increase in related jobs. The marginal effect of each of these impacts is smaller at higher catch levels and larger at lower catch levels, a consequence of the declining marginal value of catches and, therefore, participation.

Angler net benefits and regional economic impacts are also affected by changes in trip costs (figures 3, 4). Trip costs might increase as a result of increased license fees, as an unintended consequence of management actions taken to limit halibut sportfishing catches, or other changes in the supply of or demand for trips. Figure 3 illustrates that the number of angler-days fished by Alaskans is more sensitive to trip cost increases than is the number of angler-days fished by nonresidents. Consequently, if fishery managers seek to limit sportfishing catches through an equal

Table 4
Changes in Compensating Variation (CV) and Regional Economic Impacts in Response to Changes in Halibut Catch

% Change in Catch	% Change in Participation	Change in Total CV ($ million)	Change in Expenditures ($ million)	Change in Personal Income ($ million)	Change in Employment (Jobs)
−50%	−50.2%	−16.4	−16.8	−7.1	−487
−40%	−37.1%	−14.1	−12.2	−5.1	−353
−30%	−25.1%	−11.0	−8.1	−3.4	−234
−20%	−14.8%	−7.5	−4.7	−2.0	−136
−10%	−6.5%	−3.8	−2.0	−0.9	−59
0%[1]	197,556	$19.5	$28.5	$12.0	822
+10%	4.9%	3.5	1.5	0.6	43
+20%	8.5%	6.7	2.6	1.1	75
+30%	11.0%	9.4	3.3	1.4	96

[1] These values are baseline levels and provided to add a relative context to the absolute changes.

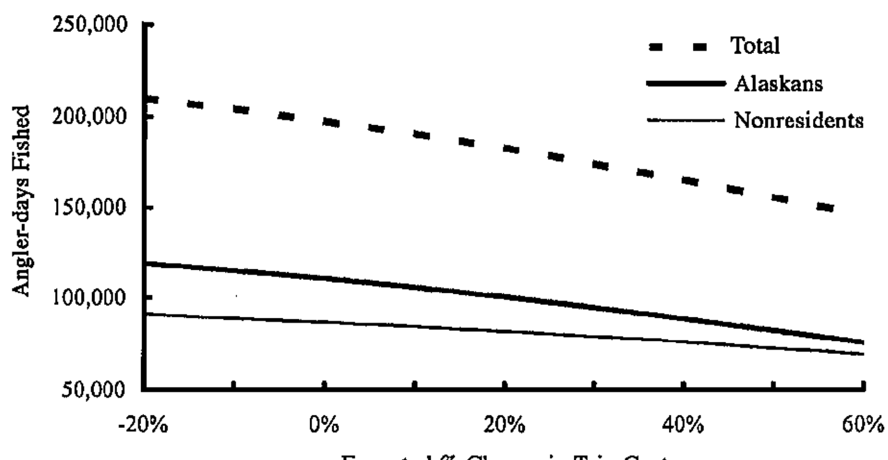


Figure 3. The Effect of Expected Fishing Trip Costs Changes on Angler Participation

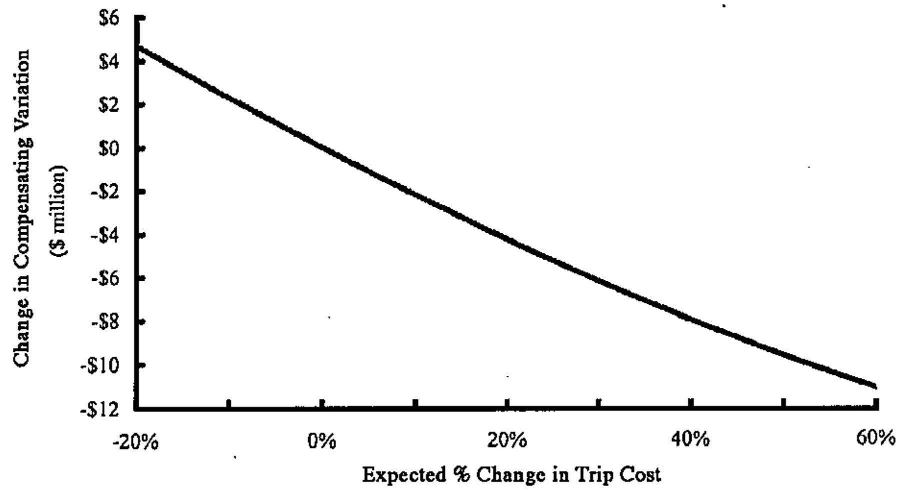


Figure 4. The Effect of Expected Fishing Trip Costs Changes on the Magnitude of Total Compensating Variation

increase in resident and nonresident license fees, the percent reduction in trips taken by Alaskans will be larger than the percent reduction in trips taken by nonresidents. Alternatively, if managers wanted to achieve identical percent reductions in resident and nonresident trips, they could impose a larger fee increase on nonresidents than residents. Moreover, if managers were strictly concerned with benefits to Alaskan resident anglers and concerned that the imposition of a binding GHL might lead to increases in the cost of charter trips, they could select a nonresident license fee that would induce a reduction in nonresident demand sufficient to choke off any upward pressure on charter trip prices. It should be noted that such fees would need to be based on the number of days fished or the number of fish caught. No such fees currently exist for halibut sportfishing in Alaska, and the authors do not necessarily advocate the creation of such fees.

The regional economic impacts of changes in trip costs are reported in table 5. Note that although participation is a linear function of trip cost, angler welfare and regional economic activity are nonlinear. The results indicate, for example, that for a $10 increase in expected trip costs, the number of angler-days fished will decline by 3.6%, net benefits to sport fishers will decrease by $2.2 million (11.3%), sportfishing related expenditures in the Kenai Peninsula region will fall by $1.1 million (4%), Kenai Peninsula Borough personal income will decline by $0.5 million (4%), and there will be a loss of 33 related jobs. Again, these effects are nonlinear, with increasingly larger impacts at increasingly higher prices.

In the participation-rate model, when estimating changes in the probability that individual fishers would take a trip, given varying trip attributes, it is assumed that the price of the trip will remain constant at P. In other words, we assume that supply is perfectly elastic. While this assumption is appropriate for shore and private trips, it is probably not entirely accurate for the charter sector. To the extent that charter trips make up a sizeable portion of sportfishing effort, and to the extent that charter trips do not exhibit perfectly elastic supply curves, there may be price adjustment, especially in the short run. For example, charter operators might respond to a short-

Table 5
Changes in Days Fished and Regional Economic Impacts in Response to Increases in the Average Cost of a Sportfishing Trip

Change in Average Trip Cost	% Change in Angler-days Fished	Change in Total CV ($ million)	Change in Expenditures ($ million)	Change in Personal Income ($ million)	Change in Employment (Jobs)
+$5	−1.8%	−1.1	−0.6	−0.2	−16
+$10	−3.6%	−2.2	−1.1	−0.5	−33
+$15	−5.6%	−3.3	−1.8	−0.7	−51
+$25	−9.7%	−5.3	−3.0	−1.3	−88
+$50	−21.3%	−9.7	−6.7	−2.8	−193
0[1]	197,556	$19,463,536	$28,524,174	$12,034,000	822

[1] The values reported in the last row are baseline levels and provided to add a relative context to the absolute changes.

run change in expected catches by lowering their prices and keeping their customer base rather than holding prices constant and losing customers as assumed in our model. While our assumption is valid in the long run, it may be somewhat unrealistic in the short run. (If there is an upward sloping supply curve for charters, then there would still be a loss in surplus associated with the charter industry when there is an environmental change; however, some of the surplus would come from producers instead of consumers.) Additionally, if price were lowered to maintain the current level of participation, there would be little regional impact outside of fish processing. Therefore, for the charter industry, our results more closely reflect long-run rather than short-run results, especially with respect to income distribution. For shore and private vessels, this is not a factor.

Conclusions

This study develops estimates of the net economic benefits that accrue to participants in the Lower and Central Cook Inlet halibut sport fisheries, the relationship between catch, size of catch, and the number of sportfishing days, and the regional (Kenai Peninsula area) economic impact of changes in the annual total number of person-days fished. The integrated model is used to explore changes in net benefits and changes in regional impacts associated with changes in trip costs and angler success. Changes in expected catch could result from predictable changes in stock abundance; conditionally predictable environmental damages resulting from minerals exploration, development, production, or transportation activities; or from controllable management actions that affect the allocation between commercial, subsistence, and sport fishers, bag and possession limits, fishing methods, or other measures that affect average catches. Changes in cost might arise as a result of predictable shifts in the demand for sportfishing; as the result of deliberate management actions such as changes in resident or nonresident license fees, stamps, or endorsements; or incidental to management actions such as the GHL or charter IFQ, which may affect the supply or character of sportfishing trips.

The advantages of our integrated model are that: changes in participation are determined by variables that are observable, predictable, or subject to management control; nonlinear preferences are easily accommodated; aggregation of the individual participation probabilities provide a method for estimating angler welfare;

and estimated changes in aggregate participation can be linked to a regional input-output model to provide estimates of the regional economic impacts of changes in trip attributes. Although the model was developed, in part, to meet the needs of environmental and regulatory impact analyses related to outer continental shelf minerals exploration, development, and production activities in the Cook Inlet Planning Area (Herrmann, Lee, Hamel, and Criddle 2001), preliminary model results have also been used in regulatory analyses related to recent management actions designed to constrain the uncompensated reallocation of halibut from the commercial fishery to the charter-based sport fishery (NPFMC 2000, 2001).

References

Aas, O. 1995. Constraints on Sportfishing and Effect of Management Actions to Increase Participation Rates in Fishing. *North American Journal of Fisheries Management* 15:631–8.

BenAkiva, M., and S.R. Lerman. 1985. *Discrete Choice Analysis: Theory and Applications to Travel Demand*. Cambridge, MA: MIT Press.

Butler, J.S., and R. Moffitt. 1982. A Computationally Efficient Quadrature Procedure for the One-Factor Multinomial Probit Model. *Econometrica* 50:761–5.

Chamberlain, G. 1982. Analysis of Covariance with Qualitative Data. *Review of Economic Studies* 47:225–38.

Cohen, M.J. 1993. *Economic Aspects of Technological Accidents: An Evaluation of the Exxon Valdez Oil Spill on Southeastern Alaska*. Ph.D. Dissertation, University of Pennsylvania, Philadelphia, PA.

Dillman, D.A. 1978. *Mail and Telephone Surveys*. New York: John Wiley & Sons.

Edwards, S.F. 1994. *An Economics Guide to Allocation of Fish Stocks Between Commercial and Recreational Fisheries*. NOAA Technical Report. Northeast Fisheries Center, National Marine Fisheries Service, Woods Hole, MA, 29 pp.

Ericsson, K.A., and H.A. Simon. 1993. *Protocol Analysis, Verbal Reports as Data*. Cambridge, MA: MIT Press.

Greene, W.H. 1997. *Econometric Analysis*. Upper Saddle River, NJ: Prentice Hall.

Guilkey, D.K., and J.L. Murphy. 1993. Estimation and Testing in the Random Effects Probit Model. *Journal of Econometrics* 59:301–17.

Hamel, C., M. Herrmann, S.T. Lee, and K.R. Criddle. 2001. *$FISH: An Economic Assessment of Lower Cook Inlet Sport Fisheries*. Department of Economics, University of Alaska Fairbanks, Fairbanks, AK, 12 pp.

Hamel, C., M. Herrmann, S.T. Lee, K.R. Criddle, and H.T. Geier. 2002. Linking Sportfishing Trip Attributes, Participation Decisions, and Regional Economic Impacts in Lower and Central Cook Inlet, Alaska. *Annals of Regional Science* 36:247–64.

Hanemann, M.W. 1999. Welfare Analysis with Discrete Choice Variables. *Valuing Recreation and the Environment: Revealed Preference Methods in Theory and Practice*, J.A. Herriges and C.L. Kling, eds., pp. 33–64. Northampton, ME: Edward Elgar.

Herrmann, M., S.T. Lee, K.R. Criddle, and C. Hamel. 2001. A Survey of Participants in the Lower and Central Cook Inlet Halibut and Salmon Sport Fisheries. *Alaska Fishery Research Bulletin* 8:107–17.

Herrmann, M., S.T. Lee, C. Hamel, and K.R. Criddle. 2001. *An Economic Assessment of the Sport Fisheries for Halibut, Chinook and Coho Salmon in Lower and Central Cook Inlet*. Final Report, Mineral Management Service-University of Alaska Coastal Marine Institute project 12-35-0001-30661 task order 14196, Fairbanks, AK, 135 pp.

Holland, S.M., and R.B. Ditton. 1992. Fishing Trip Satisfaction: A Typology of Anglers. *North American Journal of Fisheries Management* 12:28–33.

Howe, A.L., G. Fidler, C. Olnes, A.E. Bingham, and M.J. Mills. 1998. Harvest, Catch, and Participation in Alaska Sport Fisheries During 1997. Alaska Department of Fish and Game, Fishery Data Series No. 98-25, Anchorage, AK.

Jensen Consulting. 1997. *North Pacific Fishery Management Council Recreational Economic Impact Model.* Reference manual for version 3.0.

Krinsky, I., and A.L. Robb. 1986. On Approximating the Statistical Properties of Elasticities. *Review of Economic Statistics* 9:715–9.

Lee, S.T., I. Wedin, K.R. Criddle, M. Herrmann, and J. Greenberg. 1998. *Summary of Angler Survey: Saltwater Sport Fishing off the Kenai Peninsula, Alaska.* Final report, Alaska Sea Grant Award #98-403 R14-17, Fairbanks, AK, 56 pp.

Leung, P.S., and S.G. Pooley. 2001. Regional Economic Impacts of Reductions in Fisheries Production: A Supply-Driven Approach. *Marine Resource Economics* 16:251–62.

Maddala, G.S. 1987. Limited Dependent Variable Models Using Panel Data. *The Journal of Human Resources* 22:307–38.

Marine Advisory Program. 1992. After the Exxon Oil Spill. *Alaska's Marine Resources.* University of Alaska Sea Grant College Program, Fairbanks, AK.

Northern Economics. 1990. *Economic Impacts of the S.S. Glacier Bay Oil Spill.* Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage, AK, 91 pp.

NPFMC (North Pacific Fishery Management Council). 2000. *Draft Environmental Assessment/Regulatory Impact Review/Initial Regulatory Flexibility Analysis for a Regulatory Amendment to Implement Management Measures Under a Guideline Harvest Level and/or Moratorium for Halibut in Areas 2C and 3A.* North Pacific Fishery Management Council, Anchorage, AK.

___. 2001. *Draft Environmental Assessment/Regulatory Impact Review/Initial Regulatory Flexibility Analysis for a Regulatory Amendment to Incorporate the Halibut Charter Sector into the Halibut Individual Fishing Quota Program or Implement a Moratorium on Entry into the Charter Fleet for Pacific Halibut in Areas 2C and 3A.* North Pacific Fishery Management Council, Anchorage, AK.

Olson, D., and S. Lindall. 1997. *IMPLAN Professional Software, Analysis, and Data Guide*. Stillwater, MN: Minnesota IMPLAN Group.

Steinback, S.R. 1999. Regional Economic Impact Assessments of Recreational Fisheries: An Application of the IMPLAN Modeling System to Marine Party and Charter Boat Fishing in Maine. *North American Journal of Fisheries Management* 19:725–36.

Thunberg, E., S.R. Steinback, G. Gray, A. Gautam, and M. Osborn. 1999. *Summary Report of Methods and Descriptive Statistics for the 1994 Northeast Region Marine Recreational Fishing Participation Survey.* NOAA Technical Memorandum NMFSF/SPO39.

US Department of Commerce. 1996. *Magnuson-Stevens Fishery Conservation Act.* NOAA Technical Memorandum NMFS-F/SPO-23.

Veall, M.R., and K.F. Zimmermann. 1996. Pseudo-R^2 Measures for Some Common Limited Dependent Variable Models. *Journal of Economic Surveys* 10:241–59.

Appendix

There are many reasons for visiting Alaska and the Kenai Peninsula. Respondents to the UAF angler survey (Herrmann, Lee, Criddle, and Hamel 2001) cited nine primary trip purposes. Table A1 summarizes the reasons given by respondents who fished for halibut or salmon in Cook Inlet.

Table A1
Primary Purpose of Trip to Alaska

	Alaskans (non-local)	Nonresidents
Saltwater fishing in Cook Inlet	87.9%	43.0%
Visit/vacation (in Alaska) in areas outside of Kenai Peninsula	2.9%	24.4%
Visit relatives	1.7%	12.0%
Freshwater fishing on Kenai Peninsula	5.2%	11.2%
Business trip	1.2%	3.7%
Combined marine/freshwater fishing	0.0%	2.5%
Visit friends	1.2%	0.4%
Cruise ship		1.2%
Hunting		1.7%

Because there is not an exact correspondence between visits to Alaska and the desire to fish for halibut or salmon in Cook Inlet, it was necessary to adjust the total expenditure estimates to reflect those regional expenditures that are uniquely attributable to fishing in the Cook Inlet. Consequently, after discussion with fishery participants and representatives of related tourism and fishery sectors, we adopted a set of assumptions regarding what respondents would do if the Cook Inlet sportfishing portion of their trip were cancelled (table A2).

Table A2
Assumed Response of Respondents to Cancellation of the Cook Inlet Sportfishing Portion of their Trip

Main Trip Purpose	Alaskans (non-local)	Nonresidents
Saltwater fishing in Cook Inlet	Cancel entire trip to the Kenai	Cancel entire trip to the Kenai
Visit/vacation (in Alaska) in areas outside of Kenai Peninsula	Replace days on Kenai with days elsewhere in Alaska	Replace days on Kenai with days elsewhere in Alaska
Visit relatives	Take full Kenai trip	Take full Kenai trip
Freshwater fishing on Kenai Peninsula	Reduce trip length by lost fishing days	Reduce trip length by lost fishing days
Business trip	Take full Kenai trip	Take full Kenai trip
Combined marine/freshwater fishing	Reduce trip length by lost fishing days	Reduce trip length by lost fishing days
Visit friends	Take full Kenai trip	Take full Kenai trip
Cruise ship	No observations	Take full Kenai trip
Hunting	No observations	Take full Kenai trip

The total amount of effort from table A1 was combined with the assumptions of what an individual would do of the fishing trip were cancelled, to form the overall reduction in expenses associated with a reduction in Cook Inlet sportfishing effort (table A3).

Table A3
Reduction in Fishing or Visitation Rates for a 100% Reduction in Fishing Effort (days)

	Alaskans (non-local)	Nonresidents
Fishing reduction	100%	100%
Kenai living expenses	89.5%	64.0%

For example, if a person does not take a fishing trip, we assumed that there would be a 100% reduction of new money flowing into the Kenai Peninsula from marine sportfishing-related expenditures (as the trip is not taken). However, there still may be reason for the trip to be taken even if the individual does not fish. Our calculations indicate that if an Alaskan (non-local) does not fish, 89.5% of the redistribution of primary living expenditures from outside to inside the Kenai Peninsula will not take place (note that 88% of the Alaskans took their Kenai Peninsula trip primarily to engage in marine sportfishing). For nonresidents, we estimate that approximately 64.0% of the living and transportation expenditures taking place on the Kenai Peninsula are a direct result of the fishing component of the saltwater fishing trip (36% of these primary living expenditures would still take place, as there are more reasons for non-residents to visit the Kenai Peninsula than for non-local Alaskans.

Although these are very broad assumptions, and other scenarios (such as substitute fishing trips) are plausible, we believe that estimates based on these assumptions are better than estimates that assume that all trip expenditures are derived from the Cook Inlet halibut and salmon-fishing component. By reducing total expenditures attributable to fishing, we represent a conservative view which is not only more plausible, but also more defensible when valuing a fishery and calculating economic impacts of fishery changes to changes in expected fishing harvest.

ATTACHMENT 6

THE ECONOMIC IMPACT ON PLUMAS COUNTY OF ALTERNATIVE NORTHERN PIKE ERADICATION AND MANAGEMENT SCENARIOS FOR LAKE DAVIS: FINAL REPORT

The Center for Economic Development
California State University, Chico
Phone: 530-898-4598
Fax: 530-898-4734
www.csuchico.edu/cedp/

Dr. David E. Gallo
Dr. Pete Tsournos

Funded by the California Department of Fish and Game

August 24, 2006

Table of Contents

Tables

Executive Summary

Ranking the alternative methods of dealing with the northern pike problem in Lake Davis is relatively straightforward when the sole criterion is the economic impact on the Plumas County economy. The analysis contained in this report supports the conclusion that eradication is preferable to the current management program. Compared to the use of the current pike management program alone, even a failed attempt at eradication yields a better economic outcome for Plumas County. Among the alternative methods of eradication proposed scenario 3 yields the greatest local economic benefits, although scenario 1, the preferred alternative, is a close second. Both are preferable, on the basis of economic impact, to scenario 2 since the latter implies the loss of the recreational use of the lake for a full three years.

For each of the scenarios Plumas County income was estimated for a 22 year period or two eradication cycles. For the three eradication scenarios (scenarios 1-3) the total income impacts for successful eradication are \$17.82 million, \$16.19 million, and \$18.06 million (in undiscounted constant 2005 dollars) respectively. The multiple failed eradication case (one of two failed eradication cases considered, the other being just a single attempt) leads to 22 year income impacts of \$14.26 million for scenario 3, \$13.74 million for scenario 1 (the preferred alternative), and \$11.59 million for scenario 2. For all eradication scenarios, estimated income impacts, even where eradication efforts fail, exceed the contribution Lake Davis will make to Plumas County income with a continuation of the current pike management program alone (scenario 4). It is estimated that continued pike management without an attempt to eradicate the pike will generate only \$9.03 million in local income over the next 22 years.

The choice between scenarios 1 and 3 is a difficult one and one that cannot be made on the basis of economic impact alone. For the successful eradication case there is a difference of just \$18,840 in the annual effect on gross sales and a difference of \$11,041 in the estimated impact on annual local income. While the differences are greater for the failed eradication case, the disparity is insignificant relative to the gap between the successful and failed eradication cases. If eradication were to be unsuccessful, and were to be repeated periodically (every 11 years in this case), under scenario 3 annual gross business sales would average \$295,166 less (over the 22 year period used in the analysis) than for the successful case. In addition, annual income would be lower by an average of \$172,972. The disparity between impacts on gross business sales and local income are likewise significant for scenario 1, the preferred alternative. Under this option a failed eradication effort with multiple attempts would reduce average annual gross sales and local income by \$316,254 and \$185,330, respectively.

On the basis of economic impact on the Plumas County economy, a pike eradication effort by any of the proposed methods is preferable to continuing the current pike management program alone. And, since the differences in the impacts among the alternative scenarios are insignificant (at least for scenarios 1 and 3) relative to the local economic cost of a failed eradication attempt, the particular eradication method chosen should be the one having the greatest probability of success.

Introduction

Purpose of the Study

The purpose of this economic study is to examine the short- and long-term economic effects of pike and pike eradication efforts both locally and statewide. There are two key elements to the economic analysis that need to be completed in order to accomplish this purpose. The first is to estimate the economic impacts of pike eradication efforts on the Plumas County economy. Second, a travel cost study is undertaken to estimate the value of Lake Davis to all recreational users including those from outside of the county.

The study examines the economic costs and benefits of several pike eradication scenarios. It will function as an informational document for the California Department of Fish and Game (DFG) and the general public in regards to the relative economic effects of various methods to eradicate pike including the no project alternative. This economic study is being conducted separate from, but in parallel with, a joint Environmental Impact Report/Environmental Impact Statement being prepared by a private consultant under contract with the DFG.

Cautionary Notes

Study Scope

The impacts assessed in this study are limited to those non-resident users of the recreational resource directly affected by the quality of the lake and fishery. Thus the analysis focuses on non-resident anglers and boaters and thus the number of annual visitors used in the analysis is considerably smaller than what is used In the EIR/EIS.

Impacts on Local Property Values

The analysis contained within this report estimates four local economic impacts associated with pike eradication efforts at Lake Davis: gross sales, income, employment, and county government revenues. There is another possible impact that is not included and that is the potential transitory impact on local property values that might be experienced during the treatment process. There are two reasons for excluding this potential impact, the most important of which is that it is impossible to determine with any degree of precision. The excluded effect is that local recreational property might become less attractive to buyers from outside of the county. This could occur for two reasons: because the lake level has been lowered during the treatment process and thus is unavailable for a period of time that depends on the scenario chosen, or because of the adverse publicity associated with the real or imagined consequences of the treatment itself. The impact of the lake closure should, at most, be the interest cost of delaying property sales for the period of time the lake is closed and is not likely to be significant relative to the estimated impacts on local income contained in the report.

Second, the effect on property values generated by changes in local income is already included in the local economic impact estimates. Income impact estimates include the effect on property income and thus including a property value impact would involve double counting.

Some might point to the effects on property values experienced during the 1998 treatment as evidence that this impact is large and should not be excluded from the analysis contained within this report. However, examination of that evidence is likely to lead to the conclusion that the effects of closure of Lake Davis during those years cannot be separated from the other factors that affected property values in the mid to late 1990's. Rising interest rates and other national and state economic factors depressed real estate prices throughout California and recovery of real estate prices did not begin in earnest until interest rates declined after the year 2000.[1]

Economic Impact Analysis

The economic impact analysis performed for this study is used to estimate the effect on local economic activity of the various pike eradication scenarios. There are four key elements to this analysis. First, the amount of spending per visitor day is established for several important industry specific categories. This information is derived from the surveys administered at various Lake Davis boat ramps by employees of the Center for Economic Development (CED) at the California State University, Chico. Second, the total number of annual non-resident visitor days is estimated. This is accomplished using the CED surveys and counts, the DFG angler surveys, and campground usage data obtained from the U.S. Forest service. Spending per visitor day by industry sector is multiplied by the estimated total of visitor days to determine total spending by industry category. The third element of the analysis is to use the industry spending data in conjunction with the IMPLAN input-output model to calculate the annual impacts of Lake Davis recreational use on Plumas County output, income, employment, and county revenues. Fourth, adjusting for effects of fishery quality on lake usage and the amount of time the lake would be unavailable under the various pike eradication scenarios, allows computation of the relative economic impacts of the four scenarios analyzed.

---

[1] Plumas County did experience a decrease in new homes permitted (one measure of property related activity) in 1999. The decrease was from 123 in 1998 to 101 in 1999, or less than an 18% decrease. By the year 2000 housing permits had increased to 188, with increases to 191 and 260 in the next two years. By way of comparison, Lassen County experienced a decrease in new homes permitted of 31% from the 1996 peak to the activity level in 1997 and 1998, with recovery to the 1996 level delayed until 2002. Adjacent Yuba County saw a surge in building activity in 1999 (probably due in part to damage from the 1997 flood), a 62% decline in new housing permits issued in 2000, and rapid growth in building activity beginning in 2002. Sierra County experienced a decrease in new housing permits issued of almost 41% for 1997 and 1998 from the year 1996 with a return to 1996 levels in the year 2000. In general, while the timing is not precisely the same, surrounding counties experienced larger percentage downturns in late 1990's housing construction activity than did Plumas County. (DOT 2005)

While the majority of the economic impacts are likely to be felt in the City of Portola, the analysis is performed for Plumas County as a whole. It would be possible to separate the impacts for Portola from those of the remainder of the county by running the IMPLAN model at the ZIP code level. However, the authors' previous experience with IMPLAN is that the smaller the defined economic unit, the less reliable the estimates.

The local economic impacts contained in this report can be interpreted as worst case estimates. First, this is true if the county-wide impacts are assumed to represent the effect on the Portola economy. Second, there is the implicit assumption that all of those non-resident recreational users of Lake Davis will find other options outside of Plumas County. That, in fact, may not be the case and therefore a portion of the estimated visitor spending may still positively affect the local economy.[2]

Resource Valuation

Estimation of the value of the Lake Davis is accomplished using a travel cost model. The use of travel cost to estimate the demand for recreational sites was first suggested by H. Hotelling in the late 1940's. The model was further developed by Knetsch and Clawson in the 1950's and 1960's and has since gained broad acceptance among resource economists. The literature in resource and environmental economics contains numerous studies using variations on the travel cost model.

This approach to valuing a resource is based on the idea that the cost of getting to a recreational site is a measure of the value individuals place on its use. A demand curve is generated from the various travel costs and the associated number of trips. It is fundamental to economic theory that the higher the price of a good or service the smaller the quantity demanded. In the vernacular of the travel cost model this means that as travel cost increases, as it does with distance from the site, the smaller the number of trips made annually. The total value of the resource is estimated as the area under the generated demand curve but above the average travel cost for all surveyed users. In order to maintain the continuity of the economic impact analysis, the results of the travel cost study are included in Appendix A instead of the main body of the report.

Background

Plumas County

Plumas County is located in Northern California, bordered by Lassen County on the north and Sierra and Yuba counties on the south. In 2004 Plumas County had a population of 21,230 and total wage and salary employment of 7,630. The average salary per worker was $35,840. With total county personal income of $632.23 million, 2004 per capita income was $29,780, and median household income was estimated at $53,900.

[2] Sixty percent of those responding to the survey indicated that they would "definitely" or "probably" come to the area even if Lake Davis were unavailable.

Wage and salary employment grew by 50 jobs during 2004, representing a slowdown from the rate of job growth experienced in the four previous years. Most of the jobs created during 2004 were in leisure services, retail trade, construction, and agriculture, with retail trade adding 80 jobs during the year. Employment in some other sectors actually declined, with the largest decrease in the government sector which lost 81 jobs. Annual employment growth is expected to increase to 150 new jobs in 2005, and then to stabilize at between 50 and 100 new jobs annually through the year 2025.

In 2004 the Plumas county population increased by 0.6%, while the population of the incorporated city of Portola declined by 0.5%. The county's rate of population growth through the year 2025 is forecast to remain below the state average and is expected to increase at 0.6% annually for the 2005-10 period and remain well below 1% annually through 2025.

Real per capita income is forecast to increase by 1.8% in 2005, slowing to a 0.8% rate of increase over the next five years. Taxable sales are also expected to grow in 2005 at a rate above the long term trend, or by 4%, slowing to an average of 2.1% annually over the next five years. In nominal terms (unadjusted for inflation) the rate of growth in taxable sales is forecast to grow at a 4.02% annual rate through the year 2025. Through the year 2025 nominal personal income is forecast to grow at a 2.95% annual rate, with an annual real rate of growth averaging less than 0.5%. (DOT 2005)

Northern Pike in Lake Davis

Lake Davis is located in the Feather River drainage of the Sacramento River system at an elevation of 5,775 feet. The dam creating the lake was constructed by the California Department of Water Resources (DWR) in 1967. It is located near Portola in Plumas County on Big Grizzly Creek, a tributary to the middle fork of the Feather River. It has a storage capacity of 84,371 acre feet, covers 4,026 acres, and has a mean depth of 20.5 feet. (Lee 2001)

The existence of northern pike in Lake Davis was initially confirmed by an angler catch in August of 1994. Northern pike were caught with increasing frequency through 1994 and 1995 and in 1995 the DFG "...concluded that the eradication of the predatory pike was necessary in order to prevent their further spread in the state and to protect the trout fishery in Lake Davis". (Lee 2001, DFG 2003)

1997 Pike Eradication Efforts

The DFG received the necessary permits by October 1997 and on October 14, 1997 treatment with powered rotenone and liquid Nusyn-Noxfish began. The lake still held 50,000 acre feet at the time of treatment, 20,000 acre feet more than it would have had the project not been delayed by a restraining order. By late November of that year it was determined that most of the treatment chemicals had degraded except for pipernyl butoxide. The persistence of this synergistic chemical was aided by a thick icecap and low water temperatures, and because of its presence, restocking with rainbow trout was delayed until June of 1998. Unfortunately in May 1999 northern pike were again discovered in Lake Davis. (Lee 2001)

Pike Population Management

Following a May 1999 meeting between DFG Director Robert Hight and members of local communities, a task force was formed to study pike management options and to develop recommendations. Input concerning potential alternatives was sought from the public, and, fishery biologists and others having direct experience with pike population management were brought in to discuss and evaluate suggested control strategies. In January of 2000 the task force steering committee and DFG jointly authored a report entitled *Managing Northern Pike at Lake Davis: A Plan for Y2000* containing a series of recommended strategies for northern pike population control. (Lee 2001, SLDTFSC/DFG 2000)

Program Results

In September 2003 DFG published a report outlining the results of over three years of northern pike population management at Lake Davis. The report concluded that, although field crews removed 28,100 pike weighing 4,250 pounds, the yearly harvest continued to increase and pike density increased through at least the first three years of the program. There were two important adverse consequences resulting from the failure of the implemented management techniques to limit pike populations. First, due to increasing numbers of northern pike, the risk of release to downstream waterways has increased. Second, the catch rate for rainbow trout had declined substantially, falling from a rate of 0.28 per hour in 2000 to 0.12 per hour in 2003. (DFG 2003) The decline in trout fishing success in all likelihood imposed economic costs on the local economy with a 33% decrease in visitor days recorded at Lake Davis campgrounds between 2000 and 2004. (USFS 2005)

Scenarios Analyzed

Scenario 1: Preferred Alternative

Description

The preferred alternative involves drawing the lake down to a volume of between 10,000 and 20,000 acre feet and then applying a liquid rotenone formulation in order to eliminate the pike. The rotenone treatment would also extend to tributaries to the lake, wetlands, and other potentially infested areas within the Lake Davis watershed. Drawdown would take place between January and September of the project year, and depending on the rainfall year, would result in a volume of water within the lake of 10,000 to 20,000 acre feet by September of the same year. Neutralization of the rotenone will occur by one of a number of methods currently under evaluation. (DFG 2005)

Impacts on Fishery and Lake Availability

Lake Davis boat ramps will be unusable when the lake level drops below 40,000 acre feet. With the draining commencing in January of year 1 that level is likely to be reached by March of the same year. Following eradication, trout will be restocked in May of year 2 and at that time the lake will be available for the full spectrum of recreational uses. It is assumed that successful eradication of pike will lead to an improvement in the trout fishery of 100% by year 5.[3] If eradication efforts are unsuccessful it assumed that it will be a periodic effort (e.g. once every 11 years) or will be attempted just once and the trout fishery will improve by 100% by year 5 and decline to pre-treatment levels by year 11. If just one treatment is attempted the fishery quality will continue to decline after year 11 until the catch rate falls by an additional 50% by year 21.

Scenario 2: Complete Dewatering of the Reservoir

Description

This alternative involves the use of existing dam outlets and pumps and the use of additional piping and siphons. Installation of structures will be necessary in order to prevent downstream release of adult pike, juveniles, larvae, or eggs. In the summer or fall, and when lake volume reaches 90 acre feet, the remaining water and all inflow will be treated with rotenone. (DFG 2005)

Impacts on Fishery and Lake Availability

Under this alternative Lake Davis boat ramps will be unusable between March of year 1 and April of year 4. Following eradication, trout will be restocked in May of year 4. Successful eradication is assumed to lead to the same improvement in trout fishery quality described under the preferred alternative. As with the preferred option, the impact of this method will be evaluated under the alternative assumptions that eradication of pike is a successful one-time event, that it is unsuccessful and will be repeated periodically, or that it is attempted just once. The impact on catch is assumed to follow the same post treatment patterns used in the analysis of the preferred alternative.

---

[3] In 2000 the catch rate for trout in Lake Davis was 0.28 trout per hour, but by 2003 that rate had declined to 0.12, presumably due to increased predation by northern pike. Thus removal of pike from the lake should result in a comparable reversal of the catch rate, leading to more than a 100% increase in the number of trout caught per hour. Even though an increase from 0.12 to 0.28 is more than a 100% increase, it is assumed that the quality of the fishery increases by just 100%. That is because quality (and angler response to quality changes) is also affected by the size of fish caught and the average size of trout caught has increased significantly over the same period. (DFG 2003, Loomis 2005)

Scenario 3: Draw Down to 48,000 Acre Feet

Description

For this alternative the minimum lake level will be 5,767 feet above sea level and the lake volume will not fall below 48,000 acre feet. The standing water and all flowing water will be treated with liquid rotenone in the summer or fall of year 1. Until treatment occurs boat ramps will remain usable. Restocking will be done in late spring of year 2. (DFG 2005)

Impacts on Fishery and Lake Availability

This option somewhat reduces the time the lake will be unavailable (boat ramps can remain open), however since trout will not be restocked during year 1 and the lower water level will reduce the aesthetic value of the lake for recreation, use during year 1 is likely to be reduced substantially. Successful eradication is assumed to lead to the same improvement in trout fishery quality described under the preferred alternative. As with the preferred option, the impact of this method will be evaluated under the alternative assumptions that eradication of pike is a successful one-time event, that it is unsuccessful and will be repeated periodically, or that it is attempted just once. The impact on catch is assumed to follow the same post treatment patterns used in the analysis of the preferred alternative.

Scenario 4: No Action

Description

Under this option there will be no attempt to eradicate the pike from Lake Davis. The current management plan, implemented to control the numbers of pike in the lake, will be continued. This option might include continued stocking of trout, although it is likely that a change towards larger fish, less susceptible to predation by pike, will be desirable. (DFG 2005)

Impacts on Fishery and Lake Availability

If this option were chosen there would be no interruption in the availability of the lake for recreation. Under the continued stocking alternative the quality of the trout fishery it is assumed to decline with average trout populations declining 25% by year 5 and 50% by year 10. (DFG 2005)

Survey and Results

General

Surveys and visitor counts were conducted at Lake Davis on 13 days in September and October of 2005 and for 12 days during May, June, and July of 2006. Over that time interval 238 parties were surveyed representing 477 individual visitors. (See Appendix B for the actual form used). Interviews were conducted at four boat launch points including Honker Cove, Mallard Cove, Eagle Point, and Camp 5. Some refused to be surveyed, but the majority of those approached willingly participated.

There was an average of 2.01 individuals per interviewed party with 97.4% of those interviewed visiting from outside of Plumas County. The duration of the average visit was 3.14 days, while the average visiting party makes 2.09 trips to Lake Davis annually. Most visitors (87.5%) listed the primary purpose of their visit as fishing, with 5.73% visiting friends and the remainder traveling to the area for business or other recreation. 67.9% of surveyed visitors stayed in the local area, with 46.0% of those staying locally utilizing campground facilities, 18.0% staying in hotels or motels, 14.9% staying with friends, and the remainder listing "other", primarily second homes.

Visitor Spending

Local expenditures for all surveyed non-residents totaled $42,648, or $31.06 per non-resident visitor day.[4] The expenditures were entered into six separate categories for use in the local impact analysis. Local spending per visitor day was $7.06 for restaurant meals, $7.05 for lodging, $7.73 for transportation, $2.38 for fishing-related spending, $4.57 for groceries, and $2.27 for other local retail. [5]

Impact of Presence of Northern Pike

Of those surveyed 96.6% were aware of the presence of northern pike in Lake Davis. Most (85.7%) indicated that it did not affect their willingness to utilize the lake fishery. For the few individuals saying that it did affect the number of annual visits, six said the presence of northern pike in the lake increased the number of annual visits, while 16 said that knowledge reduced the number of annual visits. However, when considering the impact of pike predation on the trout catch rate, there is likely to be a substantial negative impact on annual use of the Lake Davis fishery.

Effect of Catch Rate on Annual Visits

Only 26.05% of surveyed anglers reported that they typically caught their daily limit of trout at Lake Davis. When asked if they would increase their annual visits to the lake were they to catch twice as many fish daily, 78.21% answered yes, with an average

[4] Total spending per non-resident visitor day is somewhat lower than what was used in the Preliminary Report. The additional surveys done during the summer of 2006 reduced average daily spending from $35.60 to $31.06.

[5] Due to a misunderstanding with those conducting the surveys during the May through July, 2006 period spending was reported as a total instead of being separated by expenditure category. Therefore, the total spending is allocated to the individual expenditure categories based on the surveys done during September and October of 2005. Because the majority of the surveys were collected in the earlier period and since sector spending multipliers are very similar, this approach has no significant impact on the study results.

increase in annual visitation of 122.39%. Adjusting for the percent currently catching their limit and those who indicate no impact on their annual visitation, the implication is that a doubling of the catch rate would lead to a 63.2% increase in annual visitor days.[6]

Methodology

Estimating Total Annual Visitor Days

Data Sources

In order to estimate the local economic impacts of Lake Davis recreational use it is necessary to determine the total annual visitor days for lake users from outside Plumas County. Since no actual count has been made, usage must be estimated from sampling. There are three sources of data that permit estimation of annual use. First, the U.S. Forest Service (USFS) maintains a count of individuals using their campground facilities at the lake. Second, the California Department of Fish and Game (DFG) has done angler surveys and the summary data includes a total count for the days surveyed. Third, surveys were administered and counts made during September and October of 2005 by employees of the Center for Economic Development (CED). The range of estimates annual visitor days derived from the three sets of data is 13,291 to 22,360. Table 1 summarizes the estimates and a brief description of how each estimate was obtained is included in the following three sections.

Table 1: Estimated Annual Recreational Visitor Days at Lake Davis

Primary Data Source	*Description*	*Annual Visitor Days*
USFS Campground Data	Campground use for the years 2001-2005	22,360
DFG Angler Surveys	Based on 2001 angler counts unadjusted	18,041
DFG Angler Surveys	Based on 2001 angler counts adjusted to 2005 using USFS relative campground use	13,291
DFG Angler Surveys	Based on the average of five years of count data collected between 1986 and 2004	16,344
CED Surveys	Based on the average hourly count of recreational users	20,458
CED Surveys	Based on the average hourly weekday and weekend day count of recreational users	17,697

[6] Those who currently catch their daily limit were asked if a halving (a 50% decrease) in their daily catch rate would affect the number of annual visits to Lake Davis. For those answering the question, 46.0 % said that it would decrease their annual use of the lake, with an average reported decrease of 38.09%. However, the relatively small sample size (17) makes the estimates of questionable value and they are not used in this report.

U.S. Forest Service Campground Usage Data

Campground usage data was obtained from the USFS for the years 1996 through 2005. The annual average for the ten year period was 28,807 campers with peak use in 2001, followed by a steady decline, falling to 20,653 campers by 2004. There was a slight increase in 2005 to a total of 21,569 campers. The annual use of Lake Davis in 2005 is obtained by taking the number of campers in that year and adjusting for the number who would come even if the lake were unavailable for use.

In May and June of 1998, prior to the restocking that followed chemical treatment, the total campers at the USFS Lake Davis campgrounds totaled 584, or 6.7% of the 8715 camper 1999-2005 May-June average. Assuming that the difference represents recreational users of the lake, that would imply that 20,124 of the campers are there only because of the availability of the lake. Adjusting for the percent of lake users who camp implies that total annual use by non-residents is 22,360 visitor days.

California Department of Water Resources Creel Surveys

DWR surveys were administered for a number of years, involving twenty-eight days of surveying and angler counts between late April and early November. The 2001 survey is used here for purposes of estimating total annual angler use. In that year angler counts were obtained on twenty-eight days between April 28 and November 15. A total of 542 anglers were counted, or an average of 2.647 per hour. Adjusting for the 2562 fishing hours available annually (14 hours per day for 183 days) that leads to an estimated 2001 angler use of 18,041 visitor days. Adjusting for the difference in campground use between 2001 and 2005, results in an estimated 13,291 visitor days for 2005. If the average for the five years for which the DWR completed counts is used (excluding 1998), annual visitor days are projected to be 16,344. However, since the DWR counts include anglers only, both of these figures probably underestimate total annual visitor days by at least 12.5% (87.5% are primarily visiting to fish).

Current Survey Data Collected for This Study

Survey data collected by CED employees is used to obtain two separate estimates of annual visitor days at Lake Davis. First the average number of recreational users counted per hour of surveying, 2.363, is used to estimate use for September of 2005. The estimate of 2,347 visitor days is then divided by the ratio of total campers in September to the annual total, or 12.91% for 2005. Using this approach the estimated annual non resident usage of Lake Davis for the year 2005 is 20,458 visitor days.

A second method, using separate visitor counts for weekdays and weekend days, yields a lower estimate. Hourly counts for weekend days (3.07) and for weekdays (2.45) are multiplied by the available annual weekend and weekday fishing hours (for May 15-November 15), respectively. Annual non-resident visitor days at Lake Davis for 2005 are estimated to be 17,697 using this approach.

Visitor Spending by Category

Each surveyed visitor was asked to estimate his or her local spending delineated by six expenditure categories: restaurant meals, lodging, transportation, fishing related, groceries, and other local retail. The results are included in Table 2, summarized by total reported spending and spending per visitor day.

Table 2: Local Visitor Spending by Non-Residents: Total and Expenditures Per Visitor Day

Expenditure Category	*Survey Total*	*Per Visitor Day*
Restaurant Meals	$9,692	$7.06
Lodging	$9,680	$7.05
Transportation	$10,614	$7.73
Fishing Related	$3,270	$2.38
Groceries	$6,277	$4.57
Other Local Retail	$3,115	$2.27
Total Local Spending	$42,648	$31.06

The IMPLAN Input-Output Model

In order to determine the total impact on county income and employment, direct visitor expenditures are entered into the appropriate sector of the IMPLAN model for the Plumas County economy. IMPLAN is an input-output model (I-O) that separates the economy into 509 industrial sectors, classifying each according to the primary product or service it provides. The transaction matrix is the model that estimates impacts. The transaction matrix contains the purchases and sales that occur among the various sectors. The column entries are the purchases made by a particular sector from all other sectors included in the model. The row elements are the industry destinations of the sector's sales. The I-O model permits assessment of the total impact of an initial change in income or expenditures. (MIG 2005)

The total impact is the sum of the direct, indirect, and induced impacts. The indirect impacts are the result of purchases (by the sectors directly affected) from local industries supplying inputs. The induced effects are due to the spending of additional income earned through the enhanced business activity generated by the direct impacts. The model output includes estimated impacts on output, income, employment and state and local taxes.

Estimated Local Impacts per 10,000 Visitor Days

Output, Income, Employment, and Revenue Impacts

Table 3 contains the IMPLAN model estimates of the local economic impacts for each 10,000 non-resident visitor days at Lake Davis. The estimates are generated from the direct spending by sector listed in Table 2. The effect on total output, or $414,519, is equivalent to total expenditures or gross business sales within Plumas County. However, since the value of output includes the value of inputs purchased from outside of the ounty, the output effect significantly overstates the impact on incomes within the county.[7] The second row of Table 3 includes the direct, indirect, induced, and total income impacts. Income is defined as the sum of employee compensation, proprietor income, other property income, and indirect business taxes. The direct income effect is the result of visitor spending within the sectors designated in Table 2, while the indirect income impact is derived from purchases of inputs from suppliers within the county. The induced impact is the result of spending of the added income in the industries directly and indirectly affected by the visitor spending linked to the use of Lake Davis. The total income impact is simply the sum of the direct, indirect, and induced impacts, or $242,915 per 10,000 non-resident visitor days.

The employment impacts are included in the last row of Table 3. Visitor spending by non-resident recreational users of Lake Davis generates 9.4 jobs per 10,000 visitor days. However, these are not full-time jobs, but rather they are based on the Department of Commerce definition of employment. Employee compensation per job averages $12,945, far below the average full-time wage rate ($35,840 in 2004) within the county.

Indirect business taxes are included in the income impact and total $35,739 per 10,000 visitor days. Total state and local taxes, including income taxes and contributions to social insurance, are $40,879, with sales taxes ($16,858) and property taxes ($11,412) providing the bulk of the revenues. The local share of revenues is estimated to be $15,262 per 10,000 visitor days.

Table 3: Impacts on Plumas County Output, Income, and Employment per 10,000 Non-Resident Visitor Days

Impact Type	*Direct*	*Indirect*	*Induced*	*Total*
Output	$310,600	$49,809	$54,109	$414,519
Income	$181,595	$27,663	$33,656	$242,915
Employee Compensation	$95,498	$12,862	$13,618	$121,978
Proprietor Income	$38,438	$3,078	$3,038	$44,554
Other Property Income	$18,534	$9,185	$12,926	$40,645
Indirect Business Taxes	$29,126	$2,539	$4,074	$35,739
Employment	7.9	0.7	0.8	9.4

Individual Industry Impacts

Table 4 contains the IMPLAN estimates of total income impacts by sector for the Plumas County economy. The table includes all sectors where income is affected by more than $5,000 per 10,000 visitor days ($0.50 per visitor day), and, the listed sectors receive 77% of the total income impact within the local economy. The greatest income impacts are in

[7] Output can be interpreted as gross business sales and that term is used in place of output in the summary tables at the end of the report. Since the impact of greatest concern for local businesses and employees is income, the majority of the analysis is focused on the effect on local income.

those sectors receiving the most direct visitor spending. Owners and employees in hotels and motels ($50,645); gasoline stations ($48,132); food services and drinking places ($34,794); and food and beverage stores ($27,918) receive the greatest boost to income from visitor spending linked to Lake Davis recreational use.

Table 4: Total Income Impacts by Sector per 10,000 Non-Resident Visitor Days

IMPLAN Sector Number	*Sector Description*	*Total Income Impact*
405	Food and Beverage Stores	$27,918
407	Gasoline Stations	$48,132
409	Sporting Goods	$11,045
431	Real Estate	$7,194
479	Hotels and Motels	$50,645
481	Food Services and Drinking Places	$34,794
509	Owner Occupied Dwellings	$8,379

Estimated Impacts for 2005

Income Impacts

The 2005 impact on the Plumas County economy of spending by recreational users of Lake Davis is calculated by multiplying the impacts per visitor day by the estimated visitor days for that year. Table 1 contains the various estimates for 2005 non-resident visitor days, and while the range is fairly wide (13,291 to 22,360), most of the estimates fall between 18,000 and 22,000 visitor days. Thus, the estimates contained here are based on a mid-range non-resident visitor day estimate of 20,000 with a variance of plus or minus 2,000.

Table 5 contains the estimated impacts of 2005 Lake Davis non-resident visitor spending on income of owners and employees of Plumas County businesses. The estimates include employee compensation, proprietor income, property income, and indirect business taxes. The income impact for the baseline estimate of 20,000 annual visitor days is $485,831, with a possible income impact ranging from a low of $437,238 (18,000 visitor days) to a high of $534,414 (22,000 visitor days).

Table 5: Estimated 2005 Income Impacts on the Plumas County Economy

Impact Estimate	*Direct*	*Indirect*	*Induced*	*Total*
Income: Midrange	$363,191	$55,327	$67,313	$485,831
Employee Compensation	$190,996	$25,724	$27,237	$243,955
Proprietor Income	$76,875	$6,156	$6,076	$89,107
Other Property Income	$37,068	$18,371	$25,851	$81,290
Indirect Business Taxes	$58,251	$5,078	$8,149	$71,478
Income: High	$399,510	$60,860	$74,044	$534,414
Income: Low	$326,872	$49,794	$60,582	$437,248

Estimated income impacts by industry are similarly derived from the Table 4 estimates of impacts per 10,000 visitor days. Table 6 contains the effects on industry income for all sectors receiving income of $0.50 or more per visitor day from spending by Lake Davis recreational users. The largest effect on income is in the hotel and motel sector, with a midrange impact of $101,290, and a range of estimates from a low of $91,161 to a high of $111,420. Other sectors experiencing a midrange income impact in excess of $50,000 include gasoline stations ($96,263), food services and drinking places ($69,588), and food and beverage stores ($55,836).

Table 6: Estimated 2005 Income Impacts by Industry

IMPLAN Sector Number	*Sector Description*	*Midrange*	*High*	*Low*
405	Food and Beverage Stores	$55,836	$61,420	$50,253
407	Gasoline Stations	$96,263	$105,890	$86,637
409	Sporting Goods	$22,089	$24,298	$19,880
431	Real Estate	$14,387	$15,826	$12,948
479	Hotels and Motels	$101,290	$111,420	$91,161
481	Food Services and Drinking Places	$69,588	$76,547	$62,630
509	Owner Occupied Dwellings	$16,758	$18,434	$15,083

Other Impact Measures

Income is the best measure of the contribution of Lake Davis visitor spending to the Plumas County economy, yet other measures might be useful for some purposes. The impact on county output represents the effect on gross sales, but since it includes the value of industry purchases from businesses outside of the county, it is not an appropriate measure of the impact on local income. In addition, although effects on county employment are generated by the IMPLAN model, the jobs created or sustained are neither full-time, not full-time equivalent jobs. County revenues are included in the income impact estimates as a portion of the entry for indirect business taxes.

Estimates for each of these additional impact measures are included in Table 7, with entries for the midrange, high and low estimates of total 2005 visitor days at Lake Davis. Visitor spending generates a total of $829,039 in output (gross sales) within Plumas County, with the estimated impact ranging from a low of $746,135 to a high of $911,942. A total of between 17.0 and 20.7 jobs result from that spending, with a most likely estimate of 18.8 jobs. Plumas County and the City of Portola receive revenues equal to 6.28% of local income (excluding state and federal aid). Thus estimated 2005 local revenue ranges from a low of $27,471 to a high of 33,576, with the estimate for midrange non-resident visitor days equal to $30,523.

Table 7: Estimated 2005 Impacts on Output (Gross Sales), Employment, and Plumas County Revenue

Impact Type	*Midrange*	*High*	*Low*
Output	$829,039	$911,942	$746,135
Employment	18.8	20.7	17.0
Local Revenues	$30,523	$33,576	$27,471

Study Results: Local Economic Impacts

Assumptions

Fishery Quality

Successful Eradication

With successful eradication of northern pike from Lake Davis it is assumed that the quality of the fishery will double within four years of project completion. The 2003 angler survey indicated a catch rate of 0.12 trout per hour, while in 2000 the catch rate was 0.28 trout per hour. Although the 2000 catch rate was more than double that of 2003, the average fish caught in 2003 was significantly larger. However, the assumptions that the catch rate will only double, and not until four years following completion of the eradication project, are relatively conservative. It is possible that from the anglers' prospective the quality will more than double and that improvement will be achieved in as little as two years after initial restocking. Earlier recovery of fishery quality increases the local economic benefits of both the successful and failed eradication cases.

Failed Eradication

If eradication is unsuccessful it is assumed that the fishery quality will follow a somewhat different path. Following attempted eradication it is assumed that the quality of the fishery will double within four years of project completion, however after that year the catch rate will decline until at the end of ten years it will have returned to current levels.

Visitor Response to Changes in Fishery Quality

The impact of changes in fishery quality on visitor days depends on the response of anglers to the catch rate and the timing of that response. The Lake Davis angler survey performed by the Center for Economic Development (CED) determined that a 100% increase in the catch rate will lead to a 63.2% increase in visitor days. This is very close to the 64.5% response rate from the environmental economics literature and the 63.2% figure from the survey is used in the economic impact analysis performed for each of the pike eradication and management scenarios. It is also assumed that angler visitor days are determined by the previous year's catch rate. Thus the peak for visitor days will always lag the peak for the catch rate by one year. In addition the angler response rate of 63.2% is used for both an increase and a decrease in fishery quality. (Loomis 2005)

Scenario 1: The Preferred Alternative

Table 8 includes the impacts on Plumas County income of both successful and failed eradication using the method proposed under the preferred alternative. In both cases the lake is unavailable for one year and thus for that year visitor days are assumed to be zero. In the second year visitor days return to their pretreatment levels, growing at a 13% annual rate until they reach a peak at 32,600 in year 6. The actual annual growth rate for visitor days is higher than 13% and continues beyond year 6 due to growth in population in those areas from which visitors are drawn. [8]

The income impacts are included for a 22 year period in order to extend the analysis for two treatment cycles under the failed treatment scenarios.[9] The total contribution to Plumas County income for the 22 years is $17.82 million for the successful eradication case, and, $13.74 million and $11.62 million for the two failed eradication cases.[10] For all of the scenarios the failed eradication cases are delineated according whether the attempt is repeated at 11-year intervals (failed/repeat) or done just once (failed/once). All totals are in constant 2005 dollars. Discounting at a 3% real discount rate results in a total net present value for the income impacts of $12.39 million, $9.70 million and $8.51 million for the successful and the two failed eradication cases, respectively.[11]

---

[8] The annual rate of growth in visitor days is the weighted average of the projected rates of population growth for California, the Northeastern Counties, and Washoe County Nevada. The weights are from the California Department of Water Resources (DWR 2005) survey of angler origin. The projected rates of population growth are from the California Department of Finance (DOF 2005) and the Nevada State Demographer (NSD 2005). Based on this approach regional population growth is projected to increase visitor days at Lake Davis by 1.03% annually.

[9] There are two failed eradication cases: one assuming eradication is a periodic event repeated every 10 years (11 years including the treatment period for the preferred alternative) and another where eradication fails, but is not attempted again within the 22 year period of the analysis. By including the multiple treatment case, the California Department of Fish and Game is not implying that it contemplates periodic treatments on an 11 year cycle. Obviously the intention is for the primary treatment to be successful and both the failed eradication cases are included only for purposes of comparison with scenario 4, the no action alternative.

[10] The income impacts are derived directly from the visitor day estimates. In order for the improvements in fishery quality to generate an increase in visitor days, it is necessary that potential visitors become aware of the changes in catch rate, and for that to occur, it is necessary that they choose Lake Davis as a fishing destination. For that reason it might be argued that there is a degree of uncertainty in the local income impact estimates. It is true that the level of uncertainty is greater than the 100% chance that the lake will be unavailable during the treatment period, however, anglers did return to the lake after the 1998 treatment and are likely to do so again.

[11] For each of the scenarios analyzed the 22 year totals are presented in both undiscounted and discounted form. The discounted totals place greater importance on income received in earlier years, implicitly recognizing the time value of money. A 3% real discount rate is typically used for decisions involving environmental changes and other public goods and is equal to the real interest rate on relatively risk free investments. The real interest rate is the difference between the nominal interest rate and the rate of inflation.

Table 8: Non-Resident Visitor Days and Impact on Plumas County Income for the Preferred Alternative: Successful and Failed Eradication Efforts

	Visitor Day Estimates			*Income Impacts*		
	With Population Growth			*With Population Growth*		
Years	**Successful**	**Failed/Repeat**	**Failed/Once**	**Successful**	**Failed/Repeat**	**Failed/Once**
1	0	0	0	$0	$0	$0
2	20,206	20,206	20,206	$490,796	$490,796	$490,796
3	23,066	23,066	23,066	$560,271	$560,271	$560,271
4	26,331	26,331	26,331	$639,581	$639,581	$639,581
5	30,059	30,059	30,059	$730,118	$730,118	$730,118
6	34,314	34,314	34,314	$833,470	$833,470	$833,470
7	34,667	31,440	31,440	$842,055	$763,665	$763,665
8	35,024	28,807	28,807	$850,728	$699,706	$699,706
9	35,385	26,394	26,394	$859,491	$641,104	$641,104
10	35,750	24,184	24,184	$868,343	$587,410	$587,410
11	36,118	22,158	22,158	$877,287	$538,213	$538,213
12	36,490	0	21,632	$886,323	$0	$525,434
13	36,866	22,617	21,118	$895,452	$549,357	$512,959
14	37,245	25,819	20,617	$904,676	$627,122	$500,780
15	37,629	29,473	20,128	$913,994	$715,895	$488,890
16	38,017	33,645	19,650	$923,408	$817,234	$477,283
17	38,408	38,408	19,183	$932,919	$932,919	$465,951
18	38,804	35,191	18,728	$942,528	$854,785	$454,888
19	39,203	32,244	18,283	$952,236	$783,194	$444,088
20	39,607	29,543	17,849	$962,044	$717,600	$433,544
21	40,015	27,069	17,425	$971,953	$657,499	$423,251
22	40,427	24,802	17,011	$981,964	$602,432	$413,202
Total				$17,819,638	$13,742,373	$11,624,605
Net Present Value (3% Real Discount Rate)				$12,386,630	$9,697,774	$8,507,678

Scenario 2

Scenario 2 involves drawing the lake down to its minimum capacity, and as a result, using this eradication method involves loss of recreational use of the lake for a period of three years. Table 9 includes the impacts on Plumas County income of both successful and failed eradication using the method proposed under scenario 2. In both cases the lake is unavailable for three years and thus visitor days are assumed to be zero for those years. In the fifth year visitor days return to their pretreatment levels, growing at a 13% annual rate thereafter until they reach a peak of 32,600 in year 8. As with the preferred alternative the actual annual growth rate for visitor days is higher than 13% and continues beyond year 8 as population grows within the area served by Lake Davis.

As in the case of the preferred alternative, the income impacts are included for a 22 year period in order to extend the analysis for two treatment cycles under the failed treatment scenario, but also considered is the option of treating the lake just once with this method. The total contribution to Plumas County income for the 22 years is lower than for scenario 1 at $16.19 million for the successful eradication case, and, $11.59 million and

$11.72 million for the failed eradication cases, with all in totals in constant 2005 dollars. Discounting at a 3% real discount rate results in a total net present value for the income impacts of $10.92 million, $7.89 million and $8.19 million for the successful and two failed eradication cases, respectively.

Table 9: Non-Resident Visitor Days and Impact on Plumas County Income for Scenario 2: Successful and Failed Eradication Efforts

	Visitor Day Estimates			*Income Impacts*		
	With Population Growth			*With Population Growth*		
Years	**Successful**	**Failed/Repeat**	**Failed/Once**	**Successful**	**Failed/Repeat**	**Failed/Once**
1	0	0	0	$0	$0	$0
2	0	0	0	$0	$0	$0
3	0	0	0	$0	$0	$0
4	20,624	20,624	20,624	$500,958	$500,958	$500,958
5	23,544	23,544	23,544	$571,872	$571,872	$571,872
6	26,877	26,877	26,877	$652,824	$652,824	$652,824
7	30,681	30,681	30,681	$745,235	$745,235	$745,235
8	35,024	35,024	35,024	$850,728	$850,728	$850,728
9	35,385	32,091	32,091	$859,491	$779,478	$779,478
10	35,750	29,403	29,403	$868,343	$714,194	$714,194
11	36,118	26,941	26,941	$877,287	$654,379	$654,379
12	36,490	0	26,301	$886,323	$0	$638,842
13	36,866	0	25,677	$895,452	$0	$623,674
14	37,245	0	25,067	$904,676	$0	$608,867
15	37,629	23,085	24,472	$913,994	$560,732	$594,411
16	38,017	26,353	23,891	$923,408	$640,107	$580,298
17	38,408	30,084	23,324	$932,919	$730,719	$566,520
18	38,804	34,342	22,770	$942,528	$834,156	$553,069
19	39,203	39,203	22,229	$952,236	$952,236	$539,938
20	39,607	35,920	21,701	$962,044	$872,484	$527,119
21	40,015	32,912	21,186	$971,953	$799,411	$514,603
22	40,427	30,155	20,683	$981,964	$732,459	$502,385
Total				$16,194,237	$11,591,974	$11,719,395
Net Present Value (3% Real Discount Rate)				$10,921,600	$7,893,204	$8,188,873

Scenario 3

Scenario 3 involves drawing the lake down to 48,000 acre feet, and as a result, using this eradication method involves minimal loss of recreational use of the lake. That is because all boat ramps will continue to be usable, and although the lake will not be stocked during year one of this eradication option, some fishing activity will likely continue. Table 10 includes the impacts on Plumas County income of both successful and failed eradication using this method and assuming lake use will be affected for just 50% of year 1. In this case visitor days total 10,000 for year 1 and then return to the current estimated use of 20,000 (plus the effect of population growth) in year 2. As with the other eradication options the improvement in catch rate causes visitor days grow at 13% annually until they reach a peak in year 6 (five years after completion of treatment), while actual use grows at a higher rate, reflecting population growth in the area served by Lake Davis.

The total contribution to Plumas County income for the 22 years is slightly higher than for scenarios 1 and 2 at $18.06 million for the successful eradication case, and, $14.26 million and $11.87 million for the failed eradication cases, all in constant 2005 dollars. Discounting at a 3% real discount rate results in a total net present value for the income impacts of $12.62 million of the successful eradication case, and, $10.12 million and $8.74 million for the failed eradication cases.

Table 10: Non-Resident Visitor Days and Impact on Plumas County Income for Scenario 3: Successful and Failed Eradication Efforts

	Visitor Day Estimates			*Income Impacts*		
	With Population Growth			*With Population Growth*		
Years	**Successful**	**Failed/Repeat**	**Failed/Once**	**Successful**	**Failed/Repeat**	**Failed/Once**
1	10,000	10,000	10,000	$242,896	$242,896	$242,896
2	20,206	20,206	20,206	$490,796	$490,796	$490,796
3	23,066	23,066	23,066	$560,271	$560,271	$560,271
4	26,331	26,331	26,331	$639,581	$639,581	$639,581
5	30,059	30,059	30,059	$730,118	$730,118	$730,118
6	34,314	34,314	34,314	$833,470	$833,470	$833,470
7	34,667	31,440	31,440	$842,055	$763,665	$763,665
8	35,024	28,807	28,807	$850,728	$699,706	$699,706
9	35,385	26,394	26,394	$859,491	$641,104	$641,104
10	35,750	24,184	24,184	$868,343	$587,410	$587,410
11	36,118	22,158	22,158	$877,287	$538,213	$538,213
12	36,490	11,193	21,632	$886,323	$271,878	$525,434
13	36,866	22,617	21,118	$895,452	$549,357	$512,959
14	37,245	25,819	20,617	$904,676	$627,122	$500,780
15	37,629	29,473	20,128	$913,994	$715,895	$488,890
16	38,017	33,645	19,650	$923,408	$817,234	$477,283
17	38,408	38,408	19,183	$932,919	$932,919	$465,951
18	38,804	35,191	18,728	$942,528	$854,785	$454,888
19	39,203	32,244	18,283	$952,236	$783,194	$444,088
20	39,607	29,543	17,849	$962,044	$717,600	$433,544
21	40,015	27,069	17,425	$971,953	$657,499	$423,251
22	40,427	24,802	17,011	$981,964	$602,432	$413,202
Total				$18,062,534	$14,257,147	$11,867,501
Net Present Value (3% Real Discount Rate)				$12,622,451	$10,124,286	$8,743,499

Scenario 4

Scenario 4, the no action alternative, yields the smallest contribution to Plumas county income. Although there are no years for which visitor days are zero, the postulated declining catch rate attracts fewer visitors each year through year 11. After year 10 it is assumed that the ongoing pike management program successfully halts the decline in the catch rate, but not until the quality of the fishery has declined by 50% from current levels.

As is the case for all of the eradication scenarios, population growth in the areas from which Lake Davis visitors are drawn leads to an increase in annual visitor days, in this case after the minimum is reached in year 11.

The contribution to Plumas County income of spending by Lake Davis visitors is lower than for any of the eradication scenarios. The total for the 22 years is $9.03million in 2005 dollars, while the net present value at a 3% real discount rate is $6.61 million. Even if improved methods of managing northern pike were capable of maintaining the current trout catch rate, all of the pike eradication scenarios result in more income for Plumas County. With base year visitor days at 20,000, and with population growth resulting in an annual increase in visitor days of 1.03%, the total contribution to local income for the 22 year period is $11.93 million, just 67% of the amount generated for the same period using the preferred alternative for pike eradication.

Table 11: Non-Resident Visitor Days and Impact on Plumas County Income for Scenario 4: No Action Alternative

	Visitor Day Estimates		*Income Impacts with Population Growth*
Years	*Without Population Growth*	*With Population Growth*	
1	20,000	20,000	$485,792
2	19,326	19,525	$474,258
3	18,675	19,062	$462,998
4	18,046	18,609	$452,005
5	17,438	18,167	$441,274
6	16,850	17,736	$430,797
7	16,167	17,192	$417,587
8	15,511	16,665	$404,782
9	14,882	16,154	$392,370
10	14,279	15,658	$380,339
11	13,700	15,178	$368,676
12	13,700	15,335	$372,473
13	13,700	15,493	$376,310
14	13,700	15,652	$380,186
15	13,700	15,813	$384,102
16	13,700	15,976	$388,058
17	13,700	16,141	$392,055
18	13,700	16,307	$396,093
19	13,700	16,475	$400,173
20	13,700	16,645	$404,295
21	13,700	16,816	$408,459
22	13,700	16,989	$412,666
		Total	$9,025,747
Net Present Value (3% real discount rate)			$6,608,624

Economic Impacts by Pike Management Scenario

Successful Eradication vs. Ongoing Pike Management

Table 12 includes the impacts on annual sales, income, employment, and county revenues for each of the eradication scenarios (scenarios 1-3) and the ongoing pike management scenario (scenario 4). It is clear that from the perspective of the Plumas County economy any of the eradication options, if successful, is preferable to the current pike management option. For the 22 year period covered by the analysis average annual gross sales for Plumas County businesses are higher by $682,100 for the preferred option (scenario 1) relative to ongoing pike management. Average annual Plumas County income, employment, and local revenue are also higher by $399,722, 16 jobs, and $25,113, respectively.

The economic advantage of pike eradication is somewhat greater for scenario 3 with average annual gross sales for Plumas county businesses higher than for the pike management option by $700,940 and exceeding that for the preferred option by $18,840. Income, employment, and county revenues are also somewhat higher than for the preferred option. However, the important result is that, because of the long term impact on the quality of the Lake Davis fishery, successful eradication by any of the means under consideration is preferable to the current strategy of pike management alone.

Table 12: Impacts on Plumas County Output (Gross Sales), Income, Employment, and County Revenue: Successful Eradication Scenarios (Scenarios 1-3) and Ongoing Pike Management (Scenario 4)

Average Annual Impact on Plumas County:	*Scenario Number*			
	1	*2*	*3*	*4*
Sales	$1,382,184	$1,256,110	$1,401,024	$700,084
Income	$809,984	$736,102	$821,024	$410,261
Employment	31	29	32	16
Revenue	$50,889	$46,247	$51,583	$25,776

Failed Eradication vs. Ongoing Pike Management

While the results included in Table 12 indicate that successful eradication of pike from Lake Davis would have clear economic advantages for Plumas County, the possibility that any eradication effort might fail must also be considered. In that case pike eradication would be a periodic event (every 11 years) or a one-time effort, with current management techniques employed in the interim. Table 13 includes the impact on Plumas County gross sales, income, employment, and county revenues for each of the failed repeat eradication scenarios. Table 14 includes the economic impacts for a one-time failed eradication effort. For purposes of comparison the management option is also included under scenario 4 in both Tables 13 and 14.

The results clearly indicate that repeating a failed eradication effort is preferable to the current strategy of pike management alone. Using the preferred alternative, average annual gross sales for Plumas County businesses are $365,846 higher than for the management option. Average annual Plumas County income, employment, and local revenue are also higher by $214,392, 8 jobs, and $13,470, respectively. As in the case of successful eradication, the economic advantages of scenario 3 over ongoing pike management are somewhat greater. With this scenario estimated annual gross sales of Plumas County businesses exceed those associated with scenario 4 by $405,775 and are $39,929 higher than for the preferred alternative. Income, employment, and county revenues are also somewhat higher than for the preferred option. [12]

Table 13: Impacts on Plumas County Output (Gross Sales), Income, Employment, and County Revenue: Repeat Failed Eradication Scenarios (Scenarios 1-3) and Ongoing Pike Management (Scenario 4)

Average Annual Impact on Plumas County:	*Scenario Number*			
	1	*2*	*3*	*4*
Sales	$1,065,930	$899,134	$1,105,859	$700,084
Income	$624,653	$526,908	$648,052	$410,261
Employment	24	20	25	16
Revenue	$39,245	$33,104	$40,715	$25,776

With the one-time failed eradication cases included in Table 14 there is very little difference in the annual impacts on sales, local income, employment, and local government revenue. Average annual impacts range from $901,665 to $920,505 for gross sales; from $528,391 to $539,432 for income; from 20 to 21 jobs: and from $33,197 to $33,891 for local government revenue. As in the repeat failed eradication cases, the average annual impacts exceed those of scenario 4, using ongoing pike management alone.

Table 14: Impacts on Plumas County Output (Gross Sales), Income, Employment, and County Revenue: One-Time Failed Eradication Scenarios (Scenarios 1-3) and Ongoing Pike Management (Scenario 4)

Average Annual Impact on Plumas County:	*Scenario Number*			
	1	*2*	*3*	*4*
Sales	$901,665	$909,017	$920,505	$700,084
Income	$528,391	$532,700	$539,432	$410,261
Employment	20	21	21	16
Revenue	$33,197	$33,468	$33,891	$25,776

[12] It might be argued that the advantages of a failed eradication attempt are overstated due to the assumptions regarding the period of time that the quality of the fishery can be sustained. For each of the scenarios it is assumed that the quality of the fishery improves for the first four years following the eradication project. Yet, there is clear evidence that the catch rate for Lake Davis trout had declined beginning three years after the restocking that followed the 1997-98 effort. However, the assumption of an additional year of sustained growth is reasonable since it is likely that this time around, if pike reappear in the lake, DFG will immediately implement those management techniques that have proven to be most effective. The assumption of an additional year of sustained fishery quality is simply a reflection of the value of previous management experience.

Conclusions

Ranking the alternative methods of dealing with the northern pike problem in Lake Davis is relatively straightforward when the sole criterion is the economic impact on the Plumas County economy. The conclusion based on the analysis contained within this report is that eradication is preferable to the current management program. Even a failed attempt at eradication (repeat or one-time) yields a better economic outcome for Plumas County. Among the alternative methods of eradication proposed scenario 3 yields the greatest local economic benefits, although scenario 1, the preferred alternative, is a close second. Both are preferable, on the basis of economic impact (in all but the one-time failed eradication case), to scenario 2 since the latter implies the loss of the recreational use of the lake for a full three years.

The choice between scenarios 1 and 3 is a difficult one and one that cannot be made on the basis of economic impact alone. For the successful eradication case there is a difference of just $18,840 in the annual effect on gross sales and a difference of $11,041 in the estimated impact on annual local income. While the differences are greater for the repeat failed eradication case, the disparity is insignificant relative to the gap between the successful and failed eradication cases. If eradication were to be unsuccessful, and were to be repeated periodically (every 11 years in this case), under scenario 3, annual business sales would average $295,166 less than for the successful case. In addition, annual income would be lower by an average of $172,972. The disparity between impacts on gross business sales and local income are likewise significant for scenario 1, the preferred alternative. Under this option a failed repeat eradication effort would reduce average annual gross sales and local income by $316,254 and $185,330, respectively.

On the basis of economic impact on the Plumas County economy, a pike eradication effort by any of the proposed methods is preferable to continuing the current pike management program alone. And, since the differences in the impacts among the alternative scenarios are insignificant (at least for scenarios 1 and 3) relative to the local economic cost of a failed eradication attempt, the choice of an eradication method should be made on the basis of which one has the greatest probability of success.

References

California Department of Fish and Game (DFG 2003), *History of Lake Davis Fishery and Management*, Portola field Office, Draft Report, December 15, 2003

California Department of Fish and Game (DFG 2003), *Managing Northern Pike at Lake Davis a Plan for Year 2000: Three Year Report*, September, 2003

California Department of Fish and Game (DFG 2005), *Notice of Preparation of a Draft Environmental Impact Report*, September 2005

California Department of Finance (DOF 2005), Population growth projections for California Counties through 2030, http://www.dof.ca.gov/HTML/DEMOGRAP/DRU_Publications/Projections/P3/P3.htm, December, 2005

California Department of Transportation (DOT 2005), *California: 2005-2025 County-Level Economic Forecast*, http://www.dot.ca.gov/hq/tpp/offices/ote/forecast2005/2005%20all%20county%20Forecast%20Book.pdf

California Department of Water Resources (DWR 2003a), 1986 Lake Davis Creel Census, Memorandum to Kathy Hill dated November 20, 2003

California Department of Water Resources (DWR 2003b), 1998 Lake Davis Creel Census, Memorandum to Kathy Hill dated October 8, 2003

California Department of Water Resources (DWR 2003c), 2001 Lake Davis Creel Census, Memorandum to Kathy Hill dated October 8, 2003

California Department of Water Resources (DWR 2005), Angler origin at Lake Davis 1986-2004, provided by email November, 2005

City of Portola Finance Office, Interview on with Susan Scarlett, August 21, 2006

Graham-Tomasi, T., Adamowicz, W.L. and Fletcher, J.J. (1990), *Errors of Truncation in Approximation to Expected Consumer Surplus*, Land Economics, Vol. 66, No.1, 1990, p. 50-55

Kerkvliet, Joe and Clifford Nowell (2000), *Tools for Recreation Management in Parks: the Case of the Greater Yellowstone's Blue Ribbon Fishery*, Ecological Economics, Vol. 34 (2000), p. 89-100.

Lee 2001, *Northern Pike Control at Lake Davis, California*, American Fisheries Society, 2001

Loomis 2005, *The Economic Value of Recreational Fishing & Boating to Visitors and Communities Along the Upper Snake River*, Colorado State University, Fort Collins, May 2005

Minnesota IMPLAN Group (MIG 2005), IMPLAN model using 2001 data, January 2005

Nevada State Demographer (NSD 2005), Projected population growth for Washoe County, Nevada, http://www.nsbdc.org/demographer/pubs/pop_increase.html, December 2005

Plumas County, Auditor/Controller's Office (PCAC 2006), Interview regarding property and sales tax allocations to Plumas County and the City of Portola, August 17, 2006

Plumas County Budget, http://www.countyofplumas.com/admin/2005-2006_budgetbook.pdf

Save Lake Davis Task Force Steering Committee and the California Department of fish and Game (SLDTFSC/DFG 2000), *Managing Northern Pike at Lake Davis: A Plan for Y2000*, January 2000

U.S. Census Bureau (USCB) 2005, www.census.gov

U.S. Census Bureau (USCBa) 2005, http://quickfacts.census.gov/qfd/states/06000.html

United States Forest Service (USFS 2005), Lake Davis campground use from 1996 through 2005, provided by phone October-November 2005

Appendix A

Resource Valuation

As the previous economic impact analysis has shown, improving the quality of the Lake Davis fishery, by eradicating the Northern Pike, has the potential to increase the local economic benefits of Plumas County. By improving the quality of the fishery we can expect an increase in visitation and expenditures which results in an increase in income to local businesses such as restaurants, gas station owners, motel owners, and other retail businesses. The local community in-turn also benefits as the increase in economic activity also leads to increases in employment, and local government tax revenue. However, expenditures by visitors which contribute income to the local community are costs rather than benefits to the local visitor.

In conventional economics it is generally accepted that measures of economic value should be based on the preferences of individuals. More specifically, the economic value of a resource is measured by the maximum willingness to pay to obtain a good or service. Dollars are a universally accepted measure of economic value because the amount that people are willing to pay for something reflects how much of all other for-sale goods and services they are willing to give up to get it. Under most circumstances individuals must pay an actual price or incur expenses to obtain the good. So, to determine the value that visitors place on the Lake Davis resource, economists estimate consumer surplus or net willingness to pay, which is defined as the difference between the maximum an individual is willing to pay to fish at Lake Davis versus the expenditures paid to fish Lake Davis. For example, if a visitor is willing to pay up to $90 to fish at Lake Davis and incurred $50 in expenses while traveling to and fishing Lake Davis, then the net economic value that the visitor places on Lake is $40. By taking the summation of the consumer surplus or net willingness to pay by all visitors to Lake Davis, we can estimate the value that visitors place on the Lake Davis resource. With improvement in the quality of the fishery, we would expect an increase in visitation and willingness to pay, resulting in an increase in the value of the Lake Davis resource.

Estimation of the value of Lake Davis is accomplished using a travel cost model. The use of travel cost to estimate the demand for recreational sites was first suggested by H. Hotelling in the late 1940's. The model was further developed by Knetsch and Clawson in the 1950's and 1960's and has since gained broad acceptance among resource economists. The literature in resource and environmental economics contains numerous studies using variations on the travel cost model.

This family of approaches to valuing a resource is based on the idea that the cost of getting to a recreational site is a measure of the value individuals place on its use. A demand curve is generated from the various travel costs and the associated number of trips. It is fundamental to economic theory that the higher the price of a good or service the smaller the quantity demanded. In the vernacular of the travel cost model this means that as travel cost increases, as it does with distance from the site, the smaller the number of trips made annually. The total value of the resource is estimated as the area under the generated demand curve but above the average travel cost for all surveyed users.

The individual travel cost method was chosen for the study utilizing surveys to collect data specific to each individual visitor's travel distance and demographic information. Individuals were asked about the distance traveled, travel time, the expenses they incurred traveling, the length of their trip, how much time they spent at the site, the quality of their recreation experience at the site, their perception of the site's environmental quality, characteristics of the site, and residence (used to determine whether they reside in a rural of urban area).

Data Sources

Surveys and visitor counts were conducted at Lake Davis on 13 days in September and October of 2005 and for 12 days during May, June, and July of 2006. Over that time interval 238 parties were surveyed representing 477 individual visitors. (See Appendix B for the actual form used). Interviews were conducted at four boat launch points including Honker Cove, Mallard Cove, Eagle Point, and Camp 5. Some refused to be surveyed, but the majority of those approached willingly participated.

There was an average of 2.01 individuals per interviewed party with 97.4% of those interviewed visiting from outside of Plumas County. The duration of the average visit was 3.14 days, while the average visiting party makes 2.09 trips to Lake Davis annually. Most visitors (87.5%) listed the primary purpose of their visit as fishing, with 5.73% visiting friends and the remainder traveling to the area for business or other recreation. Just fewer than 70% of surveyed visitors stayed in the local area, with 45.96% of those staying locally utilizing campground facilities, 18.01% staying in hotels or motels, 14.91% staying with friends, and the remaining 21.12% listing "other", primarily second homes.

Wage data by county is from the 2000 Census (USCB 2005). Conversion to hourly wage rates is accomplished by dividing by 1948, the average annual hours worked (USCB 2005). Driving distance is calculated from the origin ZIP codes to the destination ZIP codes and cost per mile was obtained from the AAA website.

The Model and Variables Included

The travel cost model specifies a relationship between the number of annual visitor days per travel party from a particular origin to a particular destination and the cost of the trip (travel cost). There are also four dummy variables included, one specifying whether the county of origin is urban or rural, and three that determine whether the visitor is staying at their primary residence, in a cabin or second home, staying with friends, or staying somewhere else, such as campsite or a motel/hotel. The final dummy variable specifies whether the primary purpose of visitation was to fish or to do something else.

Travel cost includes three elements. It is defined as the sum of the direct cost of the trip, the opportunity cost in terms of lost wages for the duration of the trip, and the on-site preparation time for boat launching or getting to a site for fishing. Each of these elements of travel cost is estimated in the conventional manner. Direct travel cost is equal to the cost per mile (56.2 cents) times the number of miles required to make the round trip to the site. Opportunity cost is calculated as 30 percent of the average hourly wage rate for the county of origin times the number of hours of travel time. The cost of preparation time is computed in the same manner, and for all sites is equal to one-half hour times 30 percent of the hourly wage rate. Where there is more than one individual in the fishing party it is assumed that direct travel cost is shared equally among the members.

Where a visitor chose to stay was also accounted for in the analysis. Home is equal to one if a visitor is staying in their primary home, while if a visitor stays elsewhere a value of zero is assigned. Cabin is equal to one if a visitor is staying in a cabin or second home, while if a visitor stays elsewhere a value of zero is assigned. Friend is equal to one if a visitor is staying with friends, while if a visitor stays elsewhere a value of zero is assigned. The coefficient for the cabin and friend variables are expected to be positive because we believe that a visitor is likely to stay longer or visit more often if friends or cabin are present. Conversely, the coefficient for the home variable is expected to be negative because we believe that a visitor is likely to stay over less or visit less if they must drive back to their primary residence. We also believe that the coefficient for the fish variable will be positive, given that fishing is the most popular activity in the area of study.

Whether an area is urban or rural is an important determinant of resident participation in fishing activity. Compared to residents of rural areas, there is a lower probability of an urban resident being a frequent angler (USFWS 1996). The difficulty is in distinguishing rural from urban areas. The definition adopted here is that a county with a population over 750,000 and where 30% or more of the county population lives in a city of more than 100,000 residents is urban. If the ZIP code reported on the survey entry is in an urban county the observation is assigned a zero, while if it is in a rural county a value of one is assigned.

Estimated Equation

The following equation was estimated in log-log form using ordinary least squares.

$$\mathrm{Ln}(\mathrm{Visitordays}/\mathrm{Pop}_{ij}) = a + b\,\mathrm{Ln}(\mathrm{TC}_{ij}) + c\,\mathrm{Cabin}_j + d\,\mathrm{Friends}_j + e\,\mathrm{Home}_j + f\,\mathrm{Fish}_j + g\,\mathrm{Rural}_i$$

Where, for each of the 279 observations representing 11,410 visitor days:

$\mathrm{Ln}(\mathrm{Visitordays}_{ij}/\mathrm{Pop}_{ij})$ is the dependent variable. For each observation it represents the number of visitor days by a traveling party from county of origin, i to destination, j (Lake Davis). It is equal to the number of individuals in the fishing party multiplied by the length of stay multiplied by the number of annual visits, divided by the population (in millions) of the county of origin.

TC_{ij} = travel cost from ZIP code origin, i to Lake Davis (j) =
($0.562*round trip distance in miles)/number in fishing party
+ 0.3*hourly wage rate*round trip travel time
+ 0.3*hourly wage rate*0.5 hours

$Cabin_j$ = 0 or 1 and is a dummy variable indicating whether a visitor is utilizing a cabin or second home (1) or staying someplace else (0).

$Friend_j$ = 0 or 1 and is a dummy variable indicating whether a visitor is staying with a friend (1) or staying someplace else (0).

$Home_j$ = 0 or 1 and is a dummy variable indicating whether a visitor is staying at their primary residence (1) or staying someplace else (0).

$Fish_j$ = 0 or 1 and is a dummy variable indicating whether a visitor's primary purpose for visiting is to fish (1) or something else (0).

$Rural_i$ = 0 or 1 and is a dummy variable defining the county of origin as rural (1) or urban (0)

a – g are the coefficients to be estimated

Coefficient Estimates

The estimated equation is:

$$\text{Ln(Visitordays/pop)} = -6.260177 - 1.280362\text{Ln(TC)} + 1.011768\text{Cabin} + .7397405\text{Friend} + -1.072858\text{Home} + .8982976\text{Fish} + 1.348624\text{Rural}$$

Table A1: Regression Coefficients, Standard Errors, and T-Values[13]

Variable	Coefficients	Standard Error	t Stat
Intercept	-6.260177	.6866137	-9.12*
Ln(TC)	-1.280362	.1160389	-11.03*
Cabin	1.011768	.3219867	3.14**
Friend	.7397405	.3675501	2.01**
Home	-1.072858	.2407894	-4.46*
Fish	.8982976	.353026	2.54**
Rural	1.348624	.2766694	4.87*

[13] * Indicates statistically significant variables at the 1% level or better.
** Indicates statistically significant variables at the 5% level or better.

Table A1 contains the coefficients, their respective standard errors and t-values. Table A2 includes the adjusted R-square and F-value for the regression.

Table A2: Regression Statistics: Adjusted R-Square and F-Value

Regression Statistics	
Observations	279
R Square	0.4955
Adjusted R Square	0.4844
F(6, 272)	44.53

Table A1 shows that there is a relationship, significant at the 1% confidence level, between the visitor day variable and the variables for travel cost, staying in a primary residence and counties of origin designated rural. As expected, visitor days and travel cost are negatively related, while visitor days and rural counties of origin are positively related. Visitor days and staying in a primary residence are negatively related. Staying with friends, staying in a cabin or second home, and primary purpose for visiting is to fish are significant and positively related to visitor days at the 5% level.

The 2005 Value of the Lake Davis Fishery Resource to Freshwater Anglers

Using the statistical results from the model and the visitor day use from the U.S. Forest Service (USFS), California Department of Fish and Game (DFG), and the Center for Economic Development (CED) allows estimation of the current (2005) value of the recreation opportunities at Lake Davis. To calculate net WTP on consumer surplus per visitor day for the log-log functional form, we utilize the approximation developed by Graham-Tomasi, Adamowics and Fletcher (1990), if $b < -1$:

$$CS/Q = (1/(b+1) * TC*Q),$$

where Q represents the actual per capita visitor days and TC is the travel cost corresponding to the sample average per capita visitor days. The visitors net WTP per day from the travel cost model is \$59.88. Given that nearly 87.5% of visitors indicate that the primary purpose of visiting Lake Davis is fishing, the value of \$59.88 per visitor day likely captures the value fisherman place on Lake Davis trout. The estimate of \$59.88 per visitor day is consistent with the estimated value of other trout fisheries cited in the environmental and resource economics literature. For example, Loomis (2005) has determined that trout fisheries in the intermountain west to be roughly equal to \$50 per day. The 2005 net annual economic value of Lake Davis resource to visitors is the product of the annual number of visitor days and consumer surplus per visit. Since the range of visitor days derived by the USFS, DFG, and CED varies from 17,101 to 26,170, the estimated net economic value falls somewhere between \$1,024,008 and \$1,567,060, with a probable value of \$1,425,743 (based on 23,810 visitor days).

The Impacts on the Value of the Lake Davis Fishery Resource for the Preferred Alternative and No Action Alternative Scenarios

Table A3 includes the impacts on the net resource value of Lake Davis of both successful and failed eradication using the method under the preferred alternative, scenario 1, and the no action alternative, scenario four. We once again assume that visitors respond to changes in fishery quality, with a 100% increase in catch rate leading to a 63.2% increase in visitor days. It as also assumed that angler visitor days will always lag the peak catch rate by one year. For simplicity, we also assume that net WTP per visitor day, $59.88, does not vary as fishery quality varies.[14]

Table A3: The Value of the Lake Davis Fishery Resource under Scenarios 1 and 4

	Visitor Days with Population Growth			*Resource Value*		
	Scenario 4: Management Only	*Scenario 1: Eradication*		*Scenario 1: Eradication*		*Scenario 4: Management Only*
Years		**Successful**	**Failed**	**Successful**	**Failed**	
1	23,810	0	0	$0	$0	$1,425,743
2	23,245	24,055	24,055	$1,440,428	$1,440,428	$1,391,892
3	22,693	27,460	27,460	$1,644,329	$1,644,329	$1,358,845
4	22,154	31,348	31,348	$1,877,094	$1,877,094	$1,326,582
5	21,628	35,785	35,785	$2,142,808	$2,142,808	$1,295,086
6	21,115	40,851	40,851	$2,446,136	$2,446,136	$1,264,337
7	20,467	41,271	37,429	$2,471,331	$2,241,266	$1,225,568
8	19,839	41,696	34,294	$2,496,786	$2,053,554	$1,187,987
9	19,231	42,126	31,422	$2,522,503	$1,881,564	$1,151,559
10	18,641	42,560	28,791	$2,548,484	$1,723,979	$1,116,248
11	18,070	42,998	26,379	$2,574,734	$1,579,591	$1,082,020
12	18,256	43,441	0	$2,601,253	$0	$1,093,165
13	18,444	43,889	26,925	$2,628,046	$1,612,298	$1,104,424
14	18,634	44,341	30,737	$2,655,115	$1,840,529	$1,115,800
15	18,826	44,797	35,088	$2,682,463	$2,101,067	$1,127,293
16	19,020	45,259	40,055	$2,710,092	$2,398,486	$1,138,904
17	19,216	45,725	45,725	$2,738,006	$2,738,006	$1,150,635
18	19,414	46,196	41,895	$2,766,208	$2,508,692	$1,162,486
19	19,614	46,672	38,386	$2,794,700	$2,298,583	$1,174,460
20	19,816	47,152	35,172	$2,823,485	$2,106,071	$1,186,557
21	20,020	47,638	32,226	$2,852,567	$1,929,682	$1,198,778
22	20,226	48,129	29,527	$2,881,948	$1,768,067	$1,211,126
			Total	$52,298,517	$40,332,230	$26,489,494
Net Present Value (3% Real Discount Rate)				$36,353,285	$28,461,815	$19,395,526

[14] It should be noted that there is a vast literature that indicates that WTP estimates are positively related to improvement in catch rates (see Loomis (2005) Kerkvliet and Nowell (2000)). Thus, the estimates of economic value of the Lake Davis Resource will be understated in scenarios in which catch rate improves and overstated in scenarios in which catch rate worsens.

Scenario 1: The Preferred Alternative

Once again, whether the treatment method is successful or the fails the lake is unavailable for one year and thus for that year visitor days are assumed to be zero. In the second year visitor days return to their pretreatment levels, growing at a 13% annual rate (baseline values). The actual annual growth rate for visitor days is higher than 13% and continues beyond year 6 due to growth in population in those areas from which visitors are drawn.

The scenario 1 impacts on the value of the Lake Davis fishery resource are included for a 22 year period in order to extend the analysis for two treatment cycles under the failed treatment scenario. The total net economic value of the Lake Davis resource for the 22 years is $52.30 million for the successful eradication case and $40.33 million for the failed eradication case. Discounting at a 3% real discount rate results in a total net present value for the net economic value of the Lake Davis resource of $36.35 million and $28.46 million for the successful and failed eradication cases, respectively

Scenario 4: No Action Alternative

Under scenario 4 there are no years for which visitor days are zero, however the postulated declining catch rate attracts fewer visitors each year through year 11. After year 10 it is assumed that the ongoing pike management program successfully halts the decline in the catch rate, but not until the quality of the fishery has declined by 50% from current levels. As is the case for all of the eradication scenarios, population growth in the areas from which Lake Davis visitors are drawn leads to an increase in annual visitor days, in this case after the minimum is reached in year 11.

The total net economic value of the Lake Davis resource with scenario 4 for the 22 years is $26.49 million in constant 2005 dollars. Discounting at a 3% real discount rate results in a total net present value for the net economic value of the Lake Davis resource of $19.40. Scenario 4, the no action alternative, clearly yields the smaller value to the Lake Davis resource compared to either a successful or failed attempt of eradication under scenario 1.

Appendix B

Center for Economic Development, California State University Chico
Mailing Address: CSU. Chico, Chico, CA 95929-0765, Phone: 898-4598

The Center for Economic Development at California State University, Chico, is conducting an economic impact study, funded by the California Department of fish and Game, of Lake Davis recreational activities on the Plumas County economy. All responses to questions will be kept strictly confidential.

1. Where is your place of residence?

   City, State, ZIP ______________________

2. What is the primary purpose of your visit to this area?

   a) Business ________
   b) Tourism or visiting friends ________
   c) Fishing ________
   d) Other recreation ________

3. Approximate travel time (one-way)? ________

4. Are you staying locally? Yes ________ No ________

5. Length of stay (days)? ________

6. Annual number of trips to Lake Davis? ________

7. If you will (or did) stay overnight where will (or did) you stay?
(Check as many as applicable with the number of days at each)

   a) Hotel/motel ________
   b) Friends/relatives ________
   c) Camping ________
   d) Other (Please Specify) ________

8. If Lake Davis were unavailable would you have traveled to the area?

   a) Definitely yes ________ c) Unlikely ________
   b) Probably ________ d) Definitely not ________

9. What are (will be) your total local expenditures on your trip to this area?

   a) Restaurant Meals $ ________ d) Fishing related $ ________
   b) Lodging $ ________ e) groceries $ ________
   c) Transportation $ ________ f) Other local retail $ ________

10. Are you aware of the presence in Lake Davis of the Northern-Pike, a non-native, predatory fish?

   Yes ________ No ________

11. If yes, does that knowledge affect the number of trips you make to Lake Davis Annually?

   Yes ________ No ________ Decrease? ________ Increase? ________

12. Do you usually catch your daily limit? Yes ________ No ________

13a. If your answer to the previous question was no, would you fish here more often if you caught twice as many fish daily?

   Yes ________ No ________

13b. How many additional trips would you make each year? ________

14a. If you answer to question 12 is yes, would you fish here less frequently if you caught one-half as many fish daily?

   Yes ________ No ________

14b. If so, how many fewer trips per year? ________

Appendix C

Summary of Portola Business Surveys

When Surveys Were Conducted
Surveys of Portola businesses were conducted in late April and early May over a total of three days including attempts at contacting those business owners not responding to the first round of calls

Businesses Surveyed
Businesses were surveyed in the lodging, eating and drinking places, and grocery and other retail sectors. A total of 23 businesses were included in the survey.

Response Rate
Of the 23 businesses included in the surveys, 13 did not respond either because there was no answer, they refused to answer, or phone numbers were changed and no new numbers were available. Of the 10 responding, two were in business only one year and therefore could offer no information on the effects of the 1998 eradication effort. Only five of the contacted businesses were able to answer all of the questions in the survey but eight of the respondents provided enough information for the surveys to be of some use. The description of the results includes those eight responses.

Results
The average length of time the respondents were in business was 19 years and currently they have an average of 6.45 employees. In 1998 they had an average of 4.83 employees. They estimate that 13.2% of their sales are to individuals whose primary destination is Lake Davis. During the 1998 eradication effort the average decrease in sales for those eight businesses was 8.75% with the duration of the loss averaging 9.66 months. Of the affected concerns only one laid off employees at the time with one full-time worker and three part-time workers losing their jobs. None of the surveyed businesses reported closing for any part of the year.

ATTACHMENT 7

Dean Runyan Associates

California Travel Impacts by County, 1992-2012

2013 Preliminary State & Regional Estimates

May 2014

california TRAVEL & TOURISM COMMISSION

A Joint Marketing Venture of the California Travel & Tourism Commission and the Governor's Office of Business Development (GO-Biz)

PREPARED BY

Dean Runyan Associates, Inc.
833 SW 11th Avenue, Suite 920
Portland, Oregon 97205
503.226.2973, Fax: 503.226.2984

for
California Travel & Tourism Commission
555 Capitol Avenue, Suite 1100
Sacramento, CA 95814
916.444.4429
www.visitcalifornia.com

STATE OF CALIFORNIA
Edmund G. Brown, Jr., Governor

GOVERNOR'S OFFICE OF BUSINESS DEVELOPMENT (GO-BIZ)
Mike Rossi, Senior Advisor for Jobs and Business Development, Office of the Governor

CALIFORNIA TRAVEL & TOURISM COMMISSION/DIVISION OF TOURISM
Caroline Beteta, President & CEO
Lynn Carpenter, Vice President of Marketing
Dan Mishell, Research Director

EXECUTIVE SUMMARY

This report provides detailed statewide and regional travel impact estimates for California from 1991 to 2013. The estimates for 2013 are preliminary. The report also provides detailed county estimates for 2012 and transient occupancy tax receipts for jurisdictions through the 2013 fiscal year.

2013 CALIFORNIA TRAVEL INDUSTRY SURPASSES PRE-RECESSION LEVEL

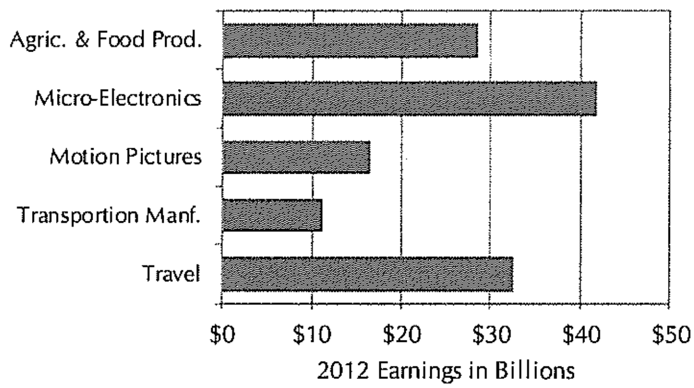
The California travel industry expanded for the fourth consecutive year following the 2007-2009 recession. In terms of both employment and real inflation-adjusted dollars, the California travel industry exceeded its pre-recession levels in 2013.

- ***Spending.*** Total direct travel spending in California was $109.6 billion in 2013(preliminary). During the past year, travel spending increased by 3.2 percent in current dollars and 2.8 percent in real (inflation-adjusted) dollars. The analogous figures for the 2011 to 2012 period were 4.3 percent and 2.2 percent. The decrease in motor fuel prices in 2013 accounted for most of the difference in the changes in current and real spending.
- ***Employment.*** Total travel-generated employment increased by 4.4 percent during the past year. Employment growth has accelerated in each of the past four years. The level of travel-generated employment (965,800) now exceeds the pre-recession period.
- ***Tax Revenues.*** The growth in local tax revenues (6.4 percent) was driven by increased lodging tax receipts due both to room demand and room rates. Travel-generated state tax revenue increased by 4.9 percent. This increase reflects the increase in the state sales tax rate of 0.25 percent. The local and state tax revenues generated by visitor spending are equivalent to $550 per resident household.
- ***Travel Activity.*** Room demand, as measured by Smith Travel Research, increased by 3.3 percent from 2012 to 2013, following a 3.6 percent increase the preceding year. This is the fourth consecutive year of increasing room demand. Visitor air arrivals on domestic flights were unchanged for the year, largely as a result of capacity limits.

THE CALIFORNIA TRAVEL INDUSTRY IS A LEADING EXPORT-ORIENTED INDUSTRY

Travel and tourism is one of the most important ***"export-oriented"*** industries in California. Spending by visitors generates sales in lodging, food services, recreation, transportation and retail businesses – the "travel industry." These sales support jobs for California residents and contribute tax revenue to local and state governments. Travel is especially important in the non-metropolitan areas of the state, where manufacturing and traded services are less prevalent.

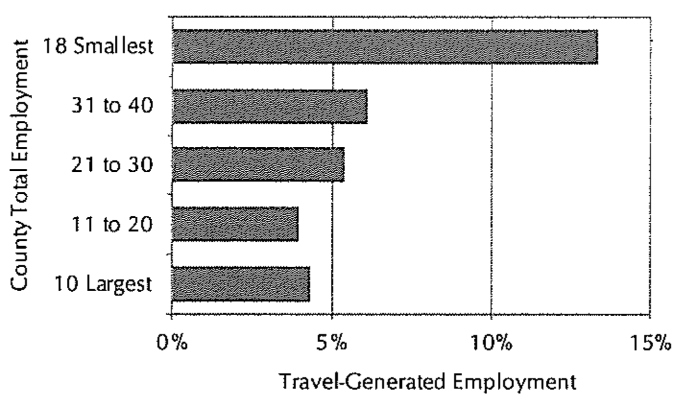
Earnings of Leading California Export-Oriented Industries



THE TRAVEL INDUSTRY BENEFITS ALL REGIONS OF CALIFORNIA

Although most travel spending and related economic impacts occur within California's primary metropolitan areas, the travel industry is important throughout California. In general, the counties with less total employment have a bigger share of travel-generated employment.

Travel-Generated Employment as a Percent of Total Employment



Households, Local Sales and Transient Occupancy Tax Receipts by County, 2012

	Total Local Tax Receipts (million)			Visitor-Generated Tax Receipts & Households			
	Local Sales	Transient Occupany	Total	Amount (million)	Percent of Total	Households (000)	Receipts per HH
Alameda	$598.1	$42.5	$640.6	$81.2	12.7%	550.9	$147
Alpine	$0.2	$0.5	$0.7	$0.6	78.0%	0.5	$1,238
Amador	$3.6	$0.8	$4.5	$1.4	30.5%	14.5	$93
Butte	$25.8	$2.7	$28.5	$4.2	14.6%	87.7	$48
Calaveras	$2.8	$0.9	$3.7	$1.4	38.0%	18.7	$76
Colusa	$3.2	$0.3	$3.5	$0.5	14.9%	7.1	$73
Contra Costa	$271.3	$9.0	$280.3	$25.5	9.1%	380.1	$67
Del Norte	$2.2	$1.2	$3.3	$1.7	51.1%	9.9	$172
El Dorado	$18.8	$8.5	$27.2	$11.5	42.2%	70.1	$164
Fresno	$200.4	$12.3	$212.7	$23.8	11.2%	292.4	$81
Glenn	$3.1	$0.6	$3.7	$0.9	24.9%	9.8	$95
Humboldt	$16.8	$4.5	$21.3	$6.2	28.9%	56.0	$110
Imperial	$36.2	$2.2	$38.3	$4.9	12.8%	49.6	$99
Inyo	$4.9	$5.0	$9.9	$6.1	61.2%	8.0	$754
Kern	$139.3	$10.4	$149.7	$17.5	11.7%	257.5	$68
Kings	$13.2	$0.5	$13.6	$1.3	9.6%	41.4	$32
Lake	$6.0	$0.9	$6.9	$1.8	25.6%	26.4	$67
Lassen	$2.3	$0.5	$2.8	$0.8	28.9%	9.9	$81
Los Angeles	$2,570.6	$354.7	$2,925.3	$555.7	19.0%	3,260.5	$170
Madera	$12.9	$3.1	$16.0	$4.3	27.1%	43.8	$99
Marin	$61.8	$12.5	$74.3	$17.5	23.6%	104.1	$168
Mariposa	$2.6	$11.7	$14.3	$13.3	93.2%	7.7	$1,733
Mendocino	$13.0	$5.8	$18.8	$7.6	40.3%	34.8	$218
Merced	$23.9	$1.3	$25.1	$2.5	10.1%	76.6	$33
Modoc	$0.9	$0.2	$1.1	$0.3	26.6%	4.0	$73
Mono	$2.2	$16.7	$18.9	$18.1	95.4%	5.8	$3,116
Monterey	$54.9	$46.6	$101.4	$57.9	57.0%	127.5	$454
Napa	$38.7	$28.3	$67.1	$35.2	52.5%	49.3	$713
Nevada	$12.9	$2.9	$15.8	$4.7	29.9%	41.5	$114

Source: Dean Runyan Associates, Inc., U.S. Bureau of the Census and California State Board of Equalization.

Local sales tax receipts reflect a 1.0 percent rate of the statewide sales tax and all other applicable city, county and district taxes.

Households, Local Sales and Transient Occupancy Tax Receipts by County, 2012

	Total Local Tax Receipts (million)			Visitor-Generated Tax Receipts & Households			
	Local Sales	Transient Occupany	Total	Amount (million)	Percent of Total	Households (000)	Receipts per HH
Orange	$787.0	$168.7	$955.7	$231.3	24.2%	1,004.9	$230
Placer	$67.1	$11.8	$78.9	$15.9	20.2%	135.3	$118
Plumas	$1.9	$0.9	$2.8	$1.4	50.3%	8.9	$157
Riverside	$400.4	$66.5	$466.9	$116.9	25.0%	697.6	$168
Sacramento	$272.0	$25.6	$297.6	$46.3	15.6%	519.1	$89
San Benito	$5.1	$0.2	$5.4	$0.7	12.9%	17.0	$41
San Bernardino	$423.6	$26.6	$450.3	$59.5	13.2%	618.5	$96
San Diego	$692.4	$185.7	$878.1	$273.1	31.1%	1,098.8	$249
San Francisco	$341.0	$336.6	$677.6	$428.8	63.3%	349.0	$1,229
San Joaquin	$137.0	$3.4	$140.4	$9.9	7.1%	217.7	$46
San Luis Obispo	$47.7	$24.1	$71.9	$30.6	42.5%	102.7	$297
San Mateo	$264.2	$52.6	$316.9	$84.3	26.6%	260.4	$324
Santa Barbara	$86.2	$37.7	$123.9	$49.7	40.1%	142.8	$348
Santa Clara	$688.2	$63.0	$751.2	$104.0	13.8%	611.5	$170
Santa Cruz	$53.7	$9.8	$63.6	$16.3	25.6%	94.8	$172
Shasta	$25.1	$4.9	$30.0	$6.9	23.0%	70.5	$98
Sierra	$0.2	$0.4	$0.6	$0.4	70.3%	1.4	$291
Siskiyou	$4.9	$2.5	$7.4	$3.3	44.6%	19.3	$171
Solano	$64.5	$3.7	$68.3	$7.6	11.1%	142.5	$53
Sonoma	$112.2	$21.9	$134.1	$34.1	25.4%	187.0	$182
Stanislaus	$76.7	$3.0	$79.7	$6.1	7.7%	166.2	$37
Sutter	$13.0	$0.5	$13.4	$0.9	6.5%	31.5	$28
Tehama	$7.1	$1.0	$8.1	$1.7	21.0%	23.8	$72
Trinity	$0.8	$0.2	$1.0	$0.3	33.2%	6.0	$55
Tulare	$57.5	$5.1	$62.5	$7.4	11.8%	132.0	$56
Tuolumne	$6.7	$2.7	$9.5	$3.8	40.0%	22.1	$172
Ventura	$113.6	$17.1	$130.7	$25.2	19.3%	268.9	$94
Yolo	$33.0	$2.7	$35.8	$4.4	12.4%	71.2	$62
Yuba	$7.0	$0.3	$7.3	$0.9	12.9%	24.4	$38
California Total	$8,932.6	$1,666.3	$10,598.9	$2,480.1	23.4%	12,691.5	$195

Source: Dean Runyan Associates, Inc., U.S. Bureau of the Census and California State Board of Equalization.

Local sales tax receipts reflect a 1.0 percent rate of the statewide sales tax and all other applicable city, county and district taxes.

ATTACHMENT 8

8/30/12 - Report on Estimated Disaster Economic Injury Worksheets for Businesses

Worksheet responses by area:

Crescent Mills	2
Greenville	4
Genesee	1
Canyon Dam	6
Lake Almanor	12
Chester	13
Belden	1
Quincy	6
Total	**45**

Worksheet responses by business type:

Food/Beverage Service	5
Rental Properties/Sales	3
Resorts/Lodging & RV Parks	12
Insurance Agencies	1
Real Estate	1
Retail	12
Riding Stables	1
Cultural Attractions	1
Auto Repair	1
Pet Grooming	1
Laundromat	1
Supermarket	1
B&B	2
General Engineering Contractor	1
Excavation/Aggregate Products	1
Upholstery & Carpet Cleaning	1

Loss of income during the period reported by the above businesses varies from 9% in Greenville to 100% in Canyon Dam (due to mandatory evacuation).

The average reported loss of income for the businesses that have submitted worksheets is 53%.

In the areas closest to the fire and smoke, namely Canyon Dam, Lake Almanor and Chester, the average percentage loss of income rises to 63%, with further losses anticipated due to cancellations received for the remainder of the season.

Several businesses report that they have still to feel the full economic effects of the disaster. Some lodging businesses that have received cancellations from tourists have managed to fill up rooms with firefighters and PG&E staff but as these people leave the area, the lodging establishments will suffer economic injury due to visitor cancellations received for the remainder of the season. The effect on rental companies is also delayed as the commission they receive is not accounted for until at least a month after the rent has been paid.

Of the five businesses worst hit by the economic downturn during this period, revenue losses equate to 96-100% with an average loss of 99%. All five of these businesses are located in Canyon Dam, Lake Almanor or Chester.

So far, the businesses surveyed have reported that 45 employees have been laid off and 6 have had their weekly hours reduced. The total revenue lost so far during the disaster is reported as $1,431,417

Other effects of the fire include, a Lake Almanor dentistry business reporting power outages that affected its computer network, resulting in a service charge to reconfigure the system (currently estimated at 200-300 dollars) plus an estimated loss of $49,336 for contents at the supermarket in Greenville.

Report on Estimated Disaster Economic Injury Worksheets for Businesses

Area	Business Type	Business Name	Owner(s) Director	Address	Impact Start/End Dates	Revenue Last Year	Revenue This Year	Loss of Revenue	Percentage Loss of Revenue	Employees Laid Off	
Crescent Mills	Retail	Crescent Country	Barbara Tucker	15771 Hwy 89	7/29/12 to 8/26/12	$9,514	$4,585	$4,929	52%	0	
2	Auto Repair	Neff Automotive	Kevin Neff	15680 Hwy 89	7/29/12 to 8/29/12	$18,494	$13,619	$4,875	36%	0	
Greenville	Retail	Sterling Sage	Alfred Huddleston	213 Main Street	7/29/12 to 8/31/12	$24,500	$15,000	$9,500	39%	0	
4	Laundromat	Indian Valley Washette	Ken Tucker	425 Crescent Street	8/1/12 to 12/31/12	$9,464	$4,732	$4,732	50%	0	
	Supermarket	Evergreen Market	Ken Tucker	429 Crescent Street	8/1/12 to 12/31/12	$1,800,000	$1,647,000	$153,000	9%	5	LOSS C ON CU
	Bar	Way Station	Gould Fickardt	224 Main Street	7/30/12 to 9/4/12	$12,500	$10,000	$2,500	20%	1 plus 2 others with hrs cut	
Genesee 1	Bistro/Deli	Genesee Store Bistro	Robert Meacher	7201 Genesee Road	8/3/12 to 9/1/12	$9,000	$4,000	$5,000	56%	0	$200
Canyon Dam	RV Campground	Forest Park RV Spaces	Joe & Crystal Elliott	29689 Hwy 89	8/1/12 to 5/15/13	$28,000	nil	$28,000	100%	Owner operated	
6	RV Park	Whispering Pines RV Park	Stuart Treff	29524 Hwy 89	8/1/12 to 5/15/13	$20,399	$2,000	$18,399	90%	Owner operated	
	Gen Engineering Contractor	Bill Davies	William Davies	5324 Hwy 147 & 5420 Seneca Road	8/1/12 to 8/31/12	$25,000	$1,000	$24,000	96%	Owner operated	CON
	Carpet & Upholstery Cleaning	High Tech Carpet Care	Stuart Treff	29524 Hwy 89	8/1/12 to 5/15/13	$5,355	$500	$4,855	91%	Owner operated	
	Guided Trail Rides	Plumas Pines Riding Stable	Deanna Vanek	3000 Almanor Dr. West	7/29/12 to 5/30/13	$13,660	$1,105	$12,555	92%	2	
	Resort	Plumas Pines Resort	Glenn Geer	3000 Almanor Dr. West	8/1/12 to 8/28/12	$246,151	$161,443	$84,708	34%	8	
Lake Almanor	Vacation Rentals & Cabin Sales	Sierra Nevada Properties - Lake Almanor Resorts	William Kerns	325 Peninsula Drive	7/29/12 to 8/26/12	$627,700	$4,200	623,500	99%	4	
12	Seasonal Golf Resort	Bailey Creek Golf Course	Kevin Hughes	433 Durkin Drive	8/12/12 to 9/8/12	$190,000	$56,000	$134,000	71%	0	
	Lodging	Longshot Lodge	Cliff Fahey	635 West Mountain Ridge Road	8/3/2012 to 8/24/12	$3,600	$2,950	$650	18%	0	
	Excavation & Aggregate Products	Turner Excavating, Inc.	Lynne Turner	3746 Big Springs Road	8/6/12 to 8/31/12	$75,000	$60,000	$15,000	20%	0	
	Lodging	Kokanee Lodge/Carson Chalets	Kimberly Carson	454 & 458 Peninsula Drive	8/4/12 to 9/3/12	$33,315	$0	$33,315	100%	2	REAL F CLEAN
	Lodging	111 Lakeside Drive	Ginny Powell	111 Lakeside Drive	8/4/12 to 9/3/12	$5,720	$0	$5,720	100%	0	REAL
	Restaurant/Deli	Carol's Café & West Shore Deli	Carol Franchetti	2932 Almanor Drive West	8/16/12 to 9/13/12	$36,195	$17,697	$18,498	51%	7	$200 REVEN
	Real Estate Brokerage	Lake Almanor Brokers	Jay Sabelman	452 Peninsula Drive	8/3/12 to 8/31/12	12000	6000	$6,000	50%	0	
	Vacation Rentals	Lake Almanor Rental Property, Inc.	Wendi Durkin	289 Clifford Dr. North	8/1/12 to 8/31/12		SEE NOTES ⟶			1 employee reduced to PT	WILL P
	Pet Grooming	Avonna's Critter Clippers	Avonna Burkman	3440 Hwy 147	8/1/12 to 8/29/12	$5,078	$2,805	$2,273	45%	1	
	Lodging & Marina	Knotty Pine Resort	Brett Womack	430 Peninsula Drive	8/1/12 to 9/1/12	$197,580	$123,269	$74,311	38%	4	
	Cabin & RV Space Rentals	Big Springs Resort	Louis Colletta	2655 Big Springs Rd.	8/10/12 to 10/31/12	$23,000	$5,000	$18,000	78%	0	
Chester	Lodging	Antlers Motel	Desta & Dan Dunlap	268 Main Street	7/29/12 to ?		SEE NOTES ⟶			0	FIREFI CANCE ESTIM UNTIL
13	Insurance	Rouland Insurance Agency	Linda Rouland	650 Main Street	8/1/12 to 8/31/12		SEE NOTES ⟶			0	
	Retail	Back Porch Consignment	Fran Gray	160 Main Street	7/29/12 to 8/25/12	$4,389	$724	$3,665	84%	Owner operated	
	Hospitality	The Bidwell House B&B Inn	Filip Laboda	112 Main Street	7/30/12 to 9/12/12	$76,246	$58,223	$18,023	24%	2	
	Retail/Fishing Guide	The Lake Almanor Fly Fishing Co.	Mary Maumoynier	181 #1 Main Street	8/3/12 to 8/24/12	$6,597	$3,052	$3,545	54%	Owner operated	
	Retail	B & B Booksellers (Books & Beyond)	Susan Bryner	140 Main Street	8/1/12 to 8/31/12	$21,243	$14,656	$6,587	31%	2	
	Retail	Candy Shoppe	Vicki Hx- Young	134 Willow Street	8/3/12 to 9/3/12	$2,526	$1,700	$826	33%	1	
	Retail Jeweler	David Price Jeweler	David Price	216 Main Street	7/28/12 to 9/1/12	confidential	confidential	confidential	18%	0	
	Retail	Good Vibrations	Ronna Ramsay	278 Main Street	8/1/12 to 9/8/12	$28,065	$10,665	$ 17,400	62%	0	
	Produce Stand/Coffee House	Jeffroes Produce and Pies	Jeff Ogle	539 Main Street	8/1/12 to 9/6/12	$59,200	$22,200	$37,000	63%	3	
	Retail - Furniture & Gifts	Wynter Willow	Robert Caton	369 Main Street	8/6/21 to 8/31/12	$9,000	$50	$8,950	99%	0	NEW E BASED

Report on Estimated Disaster Economic Injury Worksheets for Businesses

Area	Business Type	Business Name	Owner(s) Director	Address	Impact Start/End Dates	Revenue Last Year	Revenue This Year	Loss of Revenue	Percentage Loss of Revenue	Employees Laid Off	Notes
Crescent Mills	Retail	Crescent Country	Barbara Tucker	15771 Hwy 89	7/29/12 to 8/26/12	$9,514	$4,585	$4,929	52%	0	
2	Auto Repair	Neff Automotive	Kevin Neff	15680 Hwy 89	7/29/12 to 8/29/12	$18,494	$13,619	$4,875	36%	0	
Greenville	Retail	Sterling Sage	Alfred Huddleston	213 Main Street	7/29/12 to 8/31/12	$24,500	$15,000	$9,500	39%	0	
4	Laundromat	Indian Valley Washette	Ken Tucker	425 Crescent Street	8/1/12 to 12/31/12	$9,464	$4,732	$4,732	50%	0	
	Supermarket	Evergreen Market	Ken Tucker	429 Crescent Street	8/1/12 to 12/31/12	$1,800,000	$1,647,000	$153,000	9%	5	LOSS OF CONTENTS $49,336 REVENUE LOSSES ARE AN ESTIMATE BASED ON CURRENT DOWNTURN IN BUSINESS.
	Bar	Way Station	Gould Fickardt	224 Main Street	7/30/12 to 9/4/12	$12,500	$10,000	$2,500	20%	1 plus 2 others with hrs cut	
Genesee 1	Bistro/Deli	Genesee Store Bistro	Robert Meacher	7201 Genesee Road	8/3/12 to 9/1/12	$9,000	$4,000	$5,000	56%	0	$200 LOSS IN PERISHABLES
Canyon Dam	RV Campground	Forest Park RV Spaces	Joe & Crystal Elliott	29689 Hwy 89	8/1/12 to 5/15/13	$28,000	nil	$28,000	100%	Owner operated	
6	RV Park	Whispering Pines RV Park	Stuart Treff	29524 Hwy 89	8/1/12 to 5/15/13	$20,399	$2,000	$18,399	90%	Owner operated	
	Gen Engineering Contractor	Bill Davies	William Davies	5324 Hwy 147 & 5420 Seneca Road	8/1/12 to 8/31/12	$25,000	$1,000	$24,000	96%	Owner operated	CONTENTS LOSS OF $2078
	Carpet & Upholstery Cleaning	High Tech Carpet Care	Stuart Treff	29524 Hwy 89	8/1/12 to 5/15/13	$5,355	$500	$4,855	91%	Owner operated	
	Guided Trail Rides	Plumas Pines Riding Stable	Deanna Vanek	3000 Almanor Dr. West	7/29/12 to 5/30/13	$13,660	$1,105	$12,555	92%	2	
	Resort	Plumas Pines Resort	Glenn Geer	3000 Almanor Dr. West	8/1/12 to 8/28/12	$246,151	$161,443	$84,708	34%	8	
Lake Almanor	Vacation Rentals & Cabin Sales	Sierra Nevada Properties - Lake Almanor Resorts	William Kerns	325 Peninsula Drive	7/29/12 to 8/26/12	$627,700	$4,200	623,500	99%	4	
12	Seasonal Golf Resort	Bailey Creek Golf Course	Kevin Hughes	433 Durkin Drive	8/12/12 to 9/8/12	$190,000	$56,000	$134,000	71%	0	
	Lodging	Longshot Lodge	Cliff Fahey	633 West Mountain Ridge Road	8/3/2012 to 8/24/12	$3,600	$2,950	$650	18%	0	
	Excavation & Aggregate Products	Turner Excavating, Inc.	Lynne Turner	3746 Big Springs Road	8/6/12 to 8/31/12	$75,000	$60,000	$15,000	20%	0	
	Lodging	Kokanee Lodge/Carson Chalets	Kimberly Carson	454 & 458 Peninsula Drive	8/4/12 to 9/3/12	$33,315	$0	$33,315	100%	2	REAL PROPERTY DAMAGE - $4800 FOR APPLIANCES & EXTENSIVE CLEANING
	Lodging	111 Lakeside Drive	Ginny Powell	111 Lakeside Drive	8/4/12 to 9/3/12	$5,720	$0	$5,720	100%	0	REAL PROPERTY DAMAGE - $250 FOR ADDITIONAL CLEANING
	Restaurant/Deli	Carol's Café & West Shore Deli	Carol Franchetti	2932 Almanor Drive West	8/16/12 to 9/13/12	$36,195	$17,697	$18,498	51%	7	$200 LOSS IN PRODUCE DURING MANDATORY EVACUATION, LOSS OF REVENUE FROM CATERING FOR TWO CANCELLED SEPT. EVENTS = $3500
	Real Estate Brokerage	Lake Almanor Brokers	Jay Sabelman	452 Peninsula Drive	8/3/12 to 8/31/12	12000	6000	$6,000	50%	0	
	Vacation Rentals	Lake Almanor Rental Property, Inc.	Wendi Durkin	289 Clifford Dr. North	8/1/12 to 8/31/12		SEE	NOTES ⟶		1 employee reduced to PT	WILL PROVIDE UP TO DATE INFO ON 9/15 FOR AUGUST'S REVENUE
	Pet Grooming	Avonna's Critter Clippers	Avonna Burkman	3440 Hwy 147	8/1/12 to 8/29/12	$5,078	$2,805	$2,273	45%	1	
	Lodging & Marina	Knotty Pine Resort	Brett Womack	430 Peninsula Drive	8/1/12 to 9/1/12	$197,580	$123,269	$74,311	38%	4	
	Cabin & RV Space Rentals	Big Springs Resort	Louis Colletta	2655 Big Springs Rd.	8/10/12 to 10/31/12	$23,000	$5,000	$18,000	78%	0	
Chester	Lodging	Antlers Motel	Desta & Dan Dunlap	268 Main Street	7/29/12 to ?		SEE	NOTES ⟶		0	FIREFIGHTERS FILLING ROOMS DURING FIRE BUT TOURISTS HAVE CANCELLED. FULL EFFECTS OF DISASTER WILL BE FELT LATER IN SEASON. ESTIMATED REVENUES AS PAYMENT FOR AUG. WILL NOT BE RECEIVED UNTIL NOV.
13	Insurance	Rouland Insurance Agency	Linda Rouland	650 Main Street	8/1/12 to 8/31/12		SEE	NOTES ⟶		0	
	Retail	Back Porch Consignment	Fran Gray	160 Main Street	7/29/12 to 8/25/12	$4,389	$724	$3,665	84%	Owner operated	
	Hospitality	The Bidwell House B&B Inn	Filip Laboda	112 Main Street	7/30/12 to 9/12/12	$76,246	$58,223	$18,023	24%	2	
	Retail/Fishing Guide	The Lake Almanor Fly Fishing Co.	Mary Maumoynier	181 #1 Main Street	8/3/12 to 8/24/12	$6,597	$3,052	$3,545	54%	Owner operated	
	Retail	B & B Booksellers (Books & Beyond)	Susan Bryner	140 Main Street	8/1/12 to 8/31/12	$21,243	$14,656	$6,587	31%	2	
	Retail	Candy Shoppe	Vicki Hx- Young	134 Willow Street	8/3/12 to 9/3/12	$2,526	$1,700	$826	33%	1	
	Retail Jeweler	David Price Jeweler	David Price	216 Main Street	7/28/12 to 9/1/12	confidential	confidential	confidential	18%	0	
	Retail	Good Vibrations	Ronna Ramsay	278 Main Street	8/1/12 to 9/8/12	$28,065	$10,665	$ 17,400	62%	0	
	Produce Stand/Coffee House	Jeffroes Produce and Pies	Jeff Ogle	539 Main Street	8/1/12 to 9/6/12	$59,200	$22,200	$37,000	63%	3	
	Retail - Furniture & Gifts	Wynter Willow	Robert Caton	369 Main Street	8/6/21 to 8/31/12	$9,000	$50	$8,950	99%	0	NEW BUSINESS OPENED MAY 13th 2012. AUGUST ESTIMATED LOSSES BASED ON JULY INCOME
	Restaurant	Maria's Mexican Restaurant	Maria Sanchez	139 Main Street	8/1/12 to 9/14/12	confidential	confidential	confidential	50%		
	Retail	Rycraft, Inc	Robin Rycraft	168 Main Street	8/1/12 to 8/23/12	July 12 $2,297	$677	$1620 since first month of	71%	2 reduced to PT work	NEW BUSINESS OPENED MAY 13th 2012
Quincy/ Bucks Lake	Retail	Quincy Hot Spot	Lisa Driscoll	2019 E. Main Street	7/29/12 to 8/23/12	$45,352	$39,300	$6,052	13%	2	
6	Cultural Attraction	Plumas County Museum	Scott Lawson	500 Jackson Street	8/1/12 to 9/8/12	$680	$546	$134	20%	0	
	Home Rentals	Quincy Home Rentals	Cecilia Reynolds	36179 Hwy 70	8/5/12 to 9/4/12	$6,061	$2,123	$3,938	65%	Owner operated	
	Retail	Ayoobs Main Street Styles	Charlotte Smith	515 W. Main Street	7/29/12 to 8/20/12	$21,206 (Projected	$18,942	$2,264 (projected)	11% (51%)	1	WAS EXPECTED TO BE $29,781. THE LOSS OF REVENUE WOULD THEREFORE BE $10,839 = 51%
	Lodging	Ada's Place	Mike & Valerie Nellor	562 Jackson Street	8/3/12 to 8/23/12	$8,125	$6,000	$2,125	26%	Owner operated	
	B&B and Retail Store	Haskins Valley Inn	Kenneth & Dixie Nelson	16788 Bucks Lake Rd.	7/29/12 to 9/5/12	$65,754	$54,351	$11,403	17%	0	
Belden 1	RV Park/ Store/Cafe	Caribou Crossroads, Inc	Pam & Mike Hanson	16242 Hwy 70	8/5/12 to 9/4/12	$27,143	$7,578	$19,565	72%	1 PT	NO INCOME FOR 2 FULL WKS DUE TO EVACUATION. ROAD STILL CLOSED.
Total Responses 45								Total Losses $1,431,417	Average 53%	Jobs Lost 45 Hrs Reduced 6	

ATTACHMENT 9

WATER RESOURCES RESEARCH, VOL. 39, NO. 9, 1259, doi:10.1029/2002WR001799, 2003

Estimating the benefits of maintaining adequate lake levels to homeowners using the hedonic property method

John Loomis
Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, Colorado, USA

Marvin Feldman
Resource Decisions, San Francisco, California, USA

Received 25 October 2002; accepted 11 July 2003; published 18 September 2003.

[1] The hedonic property method was used to estimate residents' economic benefits from maintaining high and stable lake levels at Lake Almanor, California. Nearly a thousand property transactions over a 14-year period from 1987 to 2001 were analyzed. The linear hedonic property regression explained more than 60% of the variation in-house prices. Property prices were negatively and significantly related to the number of linear feet of exposed lake shoreline. Each additional one foot of exposed shoreline reduces the property price by \$108–\$119. A view of the lake added nearly \$31,000 to house prices, while lakefront properties sold for \$209,000 more than non-lake front properties. *INDEX TERMS:* 6314 Policy Sciences: Demand estimation; 6329 Policy Sciences: Project evaluation; *KEYWORDS:* nonmarket valuation, willingness to pay, water quality, property values

Citation: Loomis, J., and M. Feldman, Estimating the benefits of maintaining adequate lake levels to homeowners using the hedonic property method, *Water Resour. Res.*, *39*(9), 1259, doi:10.1029/2002WR001799, 2003.

1. Introduction

[2] Lakes and reservoirs are attractive areas to live near because of the high amenity levels such water resources provide to residents. Many "lakes" are actually reservoirs created for water supply and/or hydropower production. Other times natural lakes are modified to allow for additional storage and/or enhanced hydroelectric production. In either case, people generally find the lakeshore a desirable environment for building homes. The competition among buyers for lakeshore properties pushes the prices of these properties up relative to houses not on or near such lakes. Thus up to a point, the lake or reservoir provides joint benefits and the house price differential includes the capitalized amenity value of living in a lake environment. When house lots or homes resell, the new buyers pay for this amenity value in the form of higher house prices. In a benefit-cost analysis this house price differential would reflect the amenity benefits of a water project. Thus the gain in property value would measure the amenity value to residents. This amenity value should be included as a project benefit as long as it has not already been counted through the recreation value to residents.

[3] This beneficial spillover due to the lake can be reduced if the operating regime at the lake increases emphasis on meeting irrigators' call for water or production of peaking power during the summer recreation use season. The increased water diversions may leave mudflats between the property and the lake that are both unsightly and makes recreation access to the water for boating and swimming difficult. If these increases in lake fluctuations occur during peak recreation seasons when property owners are present, this may reduce the desirability of lakeshore properties, resulting in a reduction in the demand for them. This reduction in demand would in principle be translated into a reduction in the house price premium paid for that property. In a benefit-cost analysis the gain in value from meeting seasonal demands for power or irrigation water would need to be compared to the loss in use value to the homeowners and visitors [*Cordell and Bergstrom*, 1993].

[4] The trade-off between hydropower and amenity values is of particular policy relevance when a private utility company's license to operate a hydroelectric project is up for relicensing by the Federal Energy Regulatory Commission (FERC). Under the Electric Consumers Protection Act of 1986 (16 U.S.C. 791a-825r) FERC must give equal consideration to power and environmental considerations when specifying conditions of a new or renewed license. There are over 20,000 FERC licenses expiring on dams and reservoirs during the next decade [*FERC*, 1993]. Many of these lakes/reservoirs have year-round or vacation properties located on the adjacent shoreline.

[5] The first purpose of the paper is to illustrate how the hedonic property method can be applied to address this question of the influence of lake level fluctuations on property values. The analysis reported here was performed for a private utility as part of this FERC relicensing analysis. The specific empirical issue addressed in this paper is whether variations in levels of Lake Almanor in California, had any statistically significant effect on property values and if so, what was the magnitude.

2. Hedonic Property Method (HPM)

[6] To quantify the change in property values due to changes in residential amenities, economists have developed the hedonic property method (HPM) [*Rosen*, 1974].

0043-1397/03/2002WR001799

The general theory behind the HPM, lies in differentiated consumer products. Houses are a single commodity that differ in environmental attributes at their location. Consumers compete for properties that vary in the number and quality of characteristics that are present at the site. Housing price differentials therefore reflect differences in housing characteristics.

[7] *Freeman* [1993] and *Taylor* [2002] present the basic hedonic property model based on a household production function view of a consumer maximizing utility from consumer product attributes, and a composite commodity representing all other goods. Maximizing utility subject to a budget constraint results in a consumer optimum where the marginal rate of substitution between the product attribute and the composite commodity is equal to the ratio of the implicit price for the attribute and the price of the composite commodity (which is usually normalized to one). Thus this consumer utility maximization process provides the conceptual foundation for the interpretation of the implicit prices of the attribute as the consumer's willingness to pay for another unit of the attribute.

[8] *Freeman* [1993, p. 371] provides a general specification of the first stage or hedonic price function as the price of a property as a function of its structural, neighborhood, and environmental characteristics, or

$$P_i = f(S_i, N_i, Q_i) \tag{1}$$

where P_i is price of property i, S_i is structural characteristics of i, N_i is neighborhood characteristics of i, Q_i is environmental quality characteristics of i. In this application, our environmental quality attributes is a measure of the lake level.

2.1. Functional Form Issues

[9] The simplest function form to empirically estimate equation (1) is linear:

$$P_i = Bo + B1S_i + B2N_i + B3Q_i. \tag{2}$$

In this model, the marginal implicit price of the characteristic ($\partial P/\partial Q$) is simply B3. Thus the linear model has easily interpreted and transparent marginal prices. However, the linear form has some draw backs of constant marginal implicit prices and assumes the consumer can repackage characteristics.

[10] Nonlinear functional forms for the hedonic price function avoid these restrictions and yield marginal implicit prices for a characteristic that depends on the level of that particular attribute and on the level of other characteristics as well. Candidate nonlinear models include the semilog transformation of the dependent variable and a more generalized Box-Cox transformations. The Box-Cox transformation makes the interpretation of the marginal values less intuitive as the attributes are raised to exponents and it makes calculation of the marginal values far more cumbersome [*Lansford and Jones*, 1995, p. 343]. *Cropper et al.* [1988] performed a simulation exercise comparing the accuracy of different functional forms against a known true function. They found that simpler functional forms such as linear and semilog transformation outperformed more complex functional forms in the face of omitted variable bias or use of proxy variables in place of theoretically correct variables [*Cropper et al.*, 1988]. The issue of appropriate functional form is still a lively area of research and a substantial literature on possible functional forms and merits of each has developed. The interested reader should see the works of *Taylor* [2002], *Palmquist* [1991], *Cheshire and Sheppard* [1995], and *Cropper et al.* [1988].

[11] It is likely that our empirical application shares some of the features mentioned by *Cropper et al.* [1988] that make simpler functional forms desirable. Specifically, because of multicolinearity among some of the housing characteristics, we are able to include only a subset of these, and hence the included ones act as proxies for related measures of housing attributes (e.g., bedrooms is omitted due to high correlation with baths and overall house size). On the basis of the argument of Cropper et al. we adopt a semilog model for our nonlinear functional form but retain the linear to provide a more directly interpretable measure of marginal willingness to pay from the regression coefficients as well as test the sensitivity of results to different functional forms. As shown below our results are not sensitive to choice of linear or semilog functional form. The semilog model is given by:

$$\mathrm{Ln}(P_i) = Bo + B1S_i + B2N_i + B3Q_i. \tag{3}$$

In the semilog model, the marginal implicit price is given by:

$$\partial P/\partial Qi = B3^* \ P \tag{4}$$

2.2. Defining the Dependent Variable, Marginal Versus Nonmarginal WTP

[12] While the environmental amenity is related to the location of the immobile land, since most houses are permanently attached to the land, we refer to house price as the price of the fixed bundle of the house and the land, but include independent variables to control for differences in the house structure [*Freeman*, 1993, pp. 374–375]. That is, if the residential area is already developed, buyers desiring a particular location usually have to buy the house and the lot at one combined price.

[13] As noted above, in the multiple regression with house price (in dollars) as the dependent variable, the slope or regression coefficients on the house and lot locational characteristics measure the marginal willingness to pay of homeowners for a one unit change in the level of that characteristic. If a policy results in a large change (i.e., several units) in the environmental attribute the estimate of marginal willingness to pay from the regression coefficient will overstate the willingness to pay for large gains, and understate the willingness to pay to avoid large losses. This occurs because the regression coefficient is a point estimate on what is usually a nonlinear willingness to pay function [*d'Arge and Shogren*, 1989]. Extrapolating that point estimate to large changes in the quantity of the attribute is equivalent to assuming a horizontal demand curve or constant marginal value. However, like the demand curve for most goods, the demand curve for most attributes usually slope downward. This implies a diminishing marginal value for additional units of the environmental attribute and increasing marginal values for fewer units. To correctly estimate the willingness to pay for large

changes in environmental quality, requires a second step in the hedonic property analysis whereby one estimates a separate attribute demand curve [*Taylor*, 2002].

2.3. Identification Issues

[14] While the prices of the characteristics reflect both demand and supply influences, in the first stage analysis with disaggregate data it is not necessary to consider these supply influences if individual households have no power to influence prices of the attributes [*Palmquist*, 1991, p. 96]. Essentially, consumers are price takers in the housing market. This would be especially true in built out housing markets where the stock of houses are fixed. Thus an attractive feature of the first stage analysis is with information on housing characteristics and sale prices, the marginal implicit prices can be estimated for each characteristic [*Taylor*, 2002, p. 7]. Concerns about identification of demand and supply interactions are more critical in the second stage analysis when the analyst wishes to estimate the inverse demand function or marginal benefit curve for each attribute.

[15] When using the hedonic property method to estimate the willingness to pay for environmental quality in an urban area with substantial employment centers, there can also be a concern that environmental quality differences among locations can affect wage differentials as well as property value differentials. *Bloomquist et al.* [1988] developed a model and empirical example of this effect in the U.S. This interaction is ignored in our analysis as our case study site of Lake Almanor does not have significant employment opportunities, and is mainly a residential community of retirees and vacation homeowners.

2.4. Past Literature Applying Hedonic Property Method to Water Resource Management Issues

[16] There have been dozens of hedonic property studies, although relatively few relating to water quality [e.g., *Feenberg and Mills*, 1980; *Young*, 1984; *Steinnes*, 1992; *Boyle et al.*, 1999] (see *Boyle et al.* [2001] for a summary), and only one on whether lake level fluctuations have a statistically significant effect on property values [*Lansford and Jones*, 1995]. This study did find a statistically significant effect of lake level on house prices at Lake Travis in Texas.

2.5. Empirical Specification of Hedonic Price Function

[17] This general specification in equation (1) must be made specific to the particular application. Our initial empirical specification of the hedonic property model was based on the Freeman's stylized theoretical model (equation 1) and the only other application to lake levels, Lansford and Jones. In particular, our initial empirical specification was:

$$\begin{aligned}\text{Property Price} = {} & \text{Bo} + \text{B1(Baths)} + \text{B2(Bldg Size)} \\ & + \text{B3(Bldg Quality)} + \text{B4(Acres)} + \text{B5(Garage)} \\ & + \text{B6(Golf Course)} + \text{B7(Lake Distance)} \\ & + \text{B8(Lake Front)} + \text{B9(Lake View Only)} \\ & + \text{B10(Community Dummies)} - \text{B11(MintRate)} \\ & - \text{B12(Feet of Exposed Shore)} \qquad (5)\end{aligned}$$

where Property Price is the sale price of the property in year 2000 constant dollars, Baths is the number of bathrooms, BldgSize is square footage of the residence, BldgQuality is appraisers perception of the original quality of construction and current condition of the structure, Acres is the acres of land associated with the property, Garage is dummy variable for whether the property had a garage or not, GolfCourse is dummy variable for whether the property was located on a golf course, LakeDistance is distance the property was from the lake shore, LakeFront is dummy variable for whether the property was lakefront or not, LakeViewOnly is dummy variable for whether a non-lake front property had a view of the lake, Community Dummies is equal to one for Lake Almanor Country Club (LACCDUM) and Lake Almanor West (LAWESTDUM), as these areas offered additional social amenities not available in other communities, MintRate is Mortgage interest rate, Feet of Exposed Shore is number of feet of exposed shoreline of that property at the time of sale. The marginal implicit price of a characteristic is the partial derivative of the hedonic price function in equation (5) with respect to a marginal change in the attribute or "the additional amount that must be paid by any household to move to a bundle with a higher level of that characteristic, all other things being equal" [*Freeman*, 1993].

3. Data

[18] Data for the estimation consists of property transactions, property characteristics, and lake levels in the Lake Almanor, California area. Four series of data were collected to support the hedonic modeling effort: (1) sales and property characteristics data, (2) location data, (3) economic trend data, and (4) lake level data.

3.1. Sales and Property Characteristics Data

[19] Property and sales data were obtained from the Plumas County Assessor's office. This data was available from the Assessors Office in several databases which were combined into a single database which included Assessors Parcel Number (APN), address, community, sales date, selling price, number of rooms, number of bedrooms, number of bathrooms, garages, square feet, acreage, construction type, construction quality, condition, and view and lakefront characteristics. Not all of these variables could be used in the modeling because some of these variables were highly correlated (e.g., the variables for square feet, number of rooms, number of bedrooms and number of bathrooms). When explanatory variables are highly correlated they provide essentially the same information and inclusion of all of them increases the variances of the estimators. Thus in the analysis the correlated variables were dropped and just the number of bathrooms and building size were used in equation (5).

[20] The Assessors Office data were compiled for all sales which occurred in the Lake Almanor Area from 1987 to 2001. Only residential properties which sold during the study period were analyzed. Residential properties included cottages, summer homes, vacation homes, second homes, etc. Commercial buildings such as stores were excluded. The data were further limited by those for which building

characteristics were available. Because of the requirements of the regression model, only observations which have values for all of the explanatory variable can be used. This limited the analysis to 964 observations complete on all of the variables.

3.2. Economic Trend Data

[21] These data sets included inflation data, unemployment data and mortgage interest rate data. In essence, the economic data is used to eliminate the temporal influences so that the data can be pooled on an equivalent basis. This was necessary to permit the sales from the entire 14 years of historic data to be pooled and compared. The data is thus both time series (varying temporally) and cross-sectional (varying spatially around the lakeshore).

[22] The Consumer Price Index (CPI) was used to adjust all selling prices to a constant year 2000 dollar base. This adjustment removes the inflation effects from price consideration. All values discussed in this paper are in constant year 2000 dollars.

[23] The effects of differences in mortgage interest rates also influence selling price, with lower rates having a positive effect on selling price. That is, with lower rates, buyers can qualify for larger loans and this puts less pressure on buyers to negotiate a lower price, and for sellers to have to lower prices in order for buyers to qualify. The average annual mortgage interest rate for California was determined for each sale year and included in the HPM model to adjust for this effect.

[24] To correct for the effects of differences in the business cycle and their effects on housing prices, the California statewide unemployment rate was recorded for each sale year. Increases in the unemployment rate can be expected to decrease the selling price, other factors being equal because due to its proxy for recession and the fact that people do not usually buy second homes (e.g., vacation homes) during a recession. Unfortunately, the mortgage interest rate and unemployment rate were highly correlated, so we only included the mortgage interest rate in equation (5).

3.3. Lake Level Data

[25] Lake Almanor water level data were obtained for each day from 1987 to 2001. These lake level data were matched to the time of the house sale, and lagged 90 and 120 days from the recorded sale date. Using the topographic contours of the lakeshore bottom, the exposed feet of shoreline was calculated at the lake level at the two possible sale dates. We choose to use the feet of exposed shoreline (calculated for each specific property) at 90 days and 120 days prior to the recorded sale date because these dates reflected typical real estate closing periods. Thus the 90 day feet of exposed shoreline reflects the feet of exposed shoreline likely seen by the buyer just prior to deciding to purchase the property and thus initiate the transaction. The feet of exposed shoreline varies from area to area on the lake due to the topography of the lake bottom and distance from the dam. In addition, year to year variations in lake levels occur during the time period of our data, as this time horizon included several very dry years. To conserve space, regression results report the 90 day feet of exposed shoreline, but the statistical significance and marginal values for the 120 day time period are nearly identical and are available from the lead author.

4. Statistical and Property Value Results

4.1. Statistical Results

[26] To evaluate the robustness of our implicit price per foot of exposed shoreline, both linear and semilog regression equations were estimated. Both equations are identical in terms of independent variables. As reported in Table 1, the linear model has a higher explanatory power as measured by the adjusted R^2, of 0.62, while the semilog model's explanatory power is 0.45. These are respectable given the predominant cross-sectional nature of the data. Table 1 also shows regression coefficients. All but two of the linear model coefficients are statistically significant at the 10% level. In the semilog model, all but four of the coefficients are significant at the 10% level or higher.

[27] In terms of housing structure attributes, the signs of all the variables are consistent with theory. Larger houses, houses with garages and additional bathrooms all add to house price. The further the house is from the lake shoreline, the less it sells for. Houses on lakefront lots sell for substantially more than those that are not on lakefront properties. Living on a golf course adds \$40,800 to the housing value, although much less than being on the lakefront (\$209, 490).

4.2. Water Management and Policy Implications

[28] The feet of exposed shoreline has a negative sign and is statistically significant at the 1% level in the linear model and 5% level in the semilog model, indicating this disamenity reduces house prices.

[29] With the linear model, the regression coefficients themselves can be interpreted as the marginal implicit prices for the attributes. Thus each additional foot of exposed shoreline reduces the property price by \$119.44. With the semilog model, the implicit price is calculated by multiplying the coefficient by the house price [*Taylor*, 2002]. For our mean house value of \$187,400, the semilog hedonic equation yields a marginal value of \$108.32 (.000578 × 187,400). The implicit price from the semilog model is just 10% less than the linear. These implicit prices are not statistically different. That is, the 90% confidence interval on the linear model is \$60–178, while it is \$36–\$180 for the semilog model. These confidence intervals substantially overlap.

[30] As is evident from the confidence intervals, the implicit prices are not estimated as precisely as one might like despite the fact that we have over 900 observations. Thus, while there is a statistically significant effect of lake level on house prices at Lake Almanor, the magnitude of the effect is not known with precision. To put this in perspective, an additional ten feet of exposed shoreline could have an effect as little as \$360 on a house price or as much as \$1800. At the upper end of the 90% confidence interval this represents about 1% of the price of a typical house in Lake Almanor. When aggregated over the 3,950 houses in the Lake Almanor area, an additional 10 foot of exposed shoreline would result in estimates of \$1.4 million to \$5.9 million in lost amenity value to residents.

[31] In an economic efficiency analysis or what federal water resource agencies call a National Economic Devel-

Table 1. Hedonic Property Regression Results for Lake Almanor, California

Variable	Linear		Semilog	
	Coefficient	T Statistic	Coefficient	T Statistic
Constant	300696.5	11.14[a]	13.19786	74.69[a]
ACRES	20664.49	1.94[b]	0.098050	1.41
BATHS	26303.64	4.03[a]	0.108459	2.54[a]
BLDGSIZE	18.65774	2.99[a]	4.66E-05	1.14
LAKE DISTANCE	−203561.8	−2.24[b]	−1.076291	−1.81[c]
LAKEDISTSQ	251457.3	1.44	1.378780	1.21
FEETEXPSHORE	−119.4391	−3.32[a]	−0.000578	−2.46[a]
GARAGE	15338.34	2.14[b]	0.110452	2.36[b]
GOLFCOURSE	40803.33	2.97[a]	0.445598	4.95[a]
LACCDUM	8691.889	1.02	0.062107	1.12
LAWESTDUM	68034.02	5.87[a]	0.255696	3.37[a]
LAKEFRONT	209489.5	18.04[a]	0.995514	13.10[a]
MINTRATE	−2879803.	−11.44[a]	−17.78598	−10.79[a]
BLDGQUALITY	5.162968	1.63[c]	−4.00E-05	−1.93[b]
LAKE VIEWONLY	31007.31	3.98[a]	0.256732	5.03[a]
Sample Size	964		964	
Adjusted R^2	0.625		0.446	
F statistic	115.1[a]		56.28[a]	
Mean Dependent Variable	\$187, 400		\$187, 400	
Marginal value of a one foot change in exposed shoreline	\$119		\$108	

[a]Significant at the 1% level.
[b]Significant at the 5% level.
[c]Significant at the 10% level.

opment (NED) analysis, this loss in amenity value would need to be balanced by the present value gain in hydropower value, for the lake drawdown to be economically efficient. Specifically, the conceptual foundation of benefit-cost analysis involves a comparison of net willingness to pay of competing users of a resource. The hedonic property method measures the net willingness to pay of residents for the amenity, a full lake level. The alternative use of the water in our case study is hydropower production during summer peak demand for electricity. Since producing peaking power using hydropower has very low marginal cost of production compared to fossil fuel power plants, hydropower results in cost savings to society. This resource cost savings is a benefit to society. Whether it is realized as lower electricity prices to consumers (i.e., consumer surplus) or retained by utilities in the form of producer surplus, has to do with the regulation and market structure of the electricity industry in that area.

5. Conclusion

[32] The hedonic property method detected a statistically significant difference in-house prices around Lake Almanor, California due to differences in feet of exposed shoreline. This statistical effect was robust to linear versus nonlinear functional forms of the hedonic regression. While the effect was statistically significant, the mean estimates of \$108 to \$119 per foot of exposed shoreline is less than one percent of the house value. However, using the 90% upper limit of the confidence interval, a 10 foot increase in exposed shoreline would reduce the average house price in Lake Almanor by 1%. This 10 foot increase would represent about a 5% increase in the current feet of exposed shoreline over our period of study. Thus residents' concern over additional shoreline exposure from increased peaking power operations is a valid concern. From the standpoint of economic efficiency the utility and the Federal Energy Regulatory Commission would need to balance the gain in hydropower from the additional drawdown versus the loss to residents. Of course, the typography of the bottom of Lake Almanor may be different than other lakes. Shallower lakes would result in more feet of exposed shoreline for a given reduction in lake elevation, and would make it less likely that large declines in lake levels to provide hydropower or irrigation withdrawals would be economically efficient. The optimum lake level to maintain would also depend on the net benefits of the withdrawn water. Since hydropower usually has a higher value per acre foot than irrigated agriculture, it may often be economically efficient to maintain higher lake levels at reservoirs without hydropower that serve irrigated agriculture. In any case, this study demonstrates the utility of the hedonic property method to test for, and monetize the amenity effects associated with lake drawdown from any number of water management actions, whether hydropower or water supply withdrawals.

[33] **Acknowledgments.** We would like to thank the WRR editor, associate editor, and reviewers for suggestions on clarifying the paper.

References

Bloomquist, G., M. Berger, and J. Hoehn, New estimates of quality of life in urban areas, *Am. Econ. Rev.*, *78*(1), 89–107, 1988.
Boyle, K., J. Poor, and L. Taylor, Estimating the Demand for Protecting Freshwater Lakes from Eutrophication, *Am. J. Agric. Econ.*, *81*(5), 1118–1122, 1999.
Boyle, K., A. Melissa, and K. Kiel, A survey of house price hedonic studies of the impact of environmental externalities, *J. Real Estate Lit.*, *9*(2), 117–144, 2001.
Cheshire, P., and S. Sheppard, On the price of land and the value of amenities, *Economica*, *66*, 247–267, 1995.
Cordell K., and J. Bergstrom, Comparison of recreation use values among alternative reservoir water level management scenarios, *Water Resour. Res.*, *29*, 247–258, 1993.
Cropper, M., L. Deck, and K. McConnell, On the choice of functional form for hedonic price functions, *Rev. Econ. Stat.*, *70*(4), 668–675, 1988.
d'Arge, R., and J. Shogren, Non-market asset prices: A comparison of three valuation approaches, in *Valuation Methods and Policy Making in*

Environmental Economics, edited by H. Folmer and E. van Ierland, pp. 15–36, Elsevier Sci., New York, 1989.
Federal Energy Regulatory Commission (FERC), Relicense Forecast 1993–2010, Off. of Hydropower Licensing, Washington, D. C., Dec. 1993.
Feenberg, D., and E. S. Mills, A property value study, in *Measuring the Benefits of Water Pollution Abatement*, pp. 120–125, Academic, San Diego, Calif., 1980.
Freeman, A. M., III, Property value models, in *The Measurement of Environmental and Resource Values*, pp. 367–420, Johns Hopkins Univ. Press, Baltimore, Md., 1993.
Lansford, N. H., Jr., and L. L. Jones, Recreational and aesthetic value of water using hedonic price analysis, *J. Agric. Resour. Econ.*, *20*(2), 341–355, 1995.
Palmquist, R., Hedonic methods, in *Measuring the Demand for Environmental Quality*, edited by J. Braden and C. Kolstad, pp. 77–120, North-Holland, New York, 1991.
Rosen, S., Hedonic prices and implicit markets: Product differentiation in pure competition, *J. Polit. Econ.*, *82*, 34–55, 1974.
Steinnes, D., Measuring the economic value of water quality: The case of lakeshore land, *Ann. Reg. Sci.*, *26*(2), 171–176, 1992.
Taylor, L., The hedonic method, in *A Primer for Non-market Valuation*, edited by P. Champ, T. Brown, and K. Boyle, pp. 331–394, Kluwer Acad., Norwell, Mass., 2002.
Young, C. E., Perceived water quality and the value of seasonal homes, *Water Resour. Bull.*, *20*(2), 163–166, 1984.

M. Feldman, Resource Decisions, 934 Diamond Street, San Francisco, CA 94114, USA.

J. Loomis, Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, CO 80523, USA. (jloomis@lamar.colostate.edu)

ATTACHMENT 10

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Monday, March 23, 2015 4:35 PM
To: Walter, Hanspeter
Subject: Fwd: Need Help

Good Afternoon Hanspeter, I will be forwarding some emails regarding economic impacts to our area if 2105 alternatives take place. This one is from the Hospital District. - Sherrie

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Linda Wagner** <lwagner@senecahospital.org>
Date: Mon, Mar 23, 2015 at 3:36 PM
Subject: RE: Need Help
To: Sherrie Thrall <sherrie.thrall@gmail.com>

Sherrie,

Hope you had a good weekend. Here is a brief summary for us.

SHD is a district hospital, thus we rely heavily on tax funding. The amount of money we receive in taxes helps to keep us solvent, without it we would not be able to recognize a positive or "break even" net income. As it is we struggle for a positive net income with the approx. amount of $185,000- $200,000 a tax period we do receive. We have also realized a decline in the tax base over the years, any further decrease of this income source would seriously jeopardize our ability to provide health care in the community.

Secondly because we are a "seasonal" community, we also rely on the increase in population during the summer to support us through the financially unstable winter months. Our summer months carry us financially through the negative winter month cash flow issues.

SHD is very much dependent on Lake Almanor and the ability to bring in population to support the health care service provided to the community both seasonally and on a permanent basis, without Lake Almanor, access to healthcare in this area could be put at risk.

Hope this helps.

Linda

Linda Wagner MHA/MSN, FACHE

Chief Executive Officer

Seneca Healthcare District

PO Box 737

Chester, CA 96020

lwagner@senecahospital.org

O-530.258.2067

F-530.258.2068

C-530.310.2150

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Monday, March 23, 2015 4:36 PM
To: Walter, Hanspeter
Subject: Fwd: Help Needed

This from the fire district in Chester. - Sherrie

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Joe Waterman** <joewaterman.cpud@frontier.com>
Date: Mon, Mar 23, 2015 at 3:16 PM
Subject: RE: Help Needed
To: Sherrie Thrall <sherrie.thrall@gmail.com>

Greetings!

As far as Chester is concerned, any degradation that affects property values will negatively affect our capability to fiscally provide the level of service that we currently provide. To further erode our tax base would require an adjustment in services provided with our fire response, which would negatively impact our Insurance Services Organization (ISO) rating. This would increase the cost of property insurance to the citizens of our district further compounding the ability to afford to live in the area. We already have a significant amount of funding unavailable to us via tax base and assessments due to the default of property owners and cannot afford any impacts that would increase the default rates that we are experiencing. The provision of other essential services provided by our District (Water delivery, Wastewater treatment, Solid Waste Management and Streetlight provision) would suffer similarly.

Our fire and ambulance services rely heavily on volunteer firefighters to operate effectively. Any impact, such as reduced tourism, increased cost of living, loss of employment opportunities, etc., that discourages population growth and encourages population decline will have a drastic effect on Chester Public Utility District to provide the services that this community demands and deserves.

I hope that this brief synopsis helps, and thank you for the job that you do for us!

Joe Waterman

General Manager / Chief

Chester Public Utility District

Chester Fire Department

Plumas County OES Operational Area Coordinator

(530) 258-2171 Office

(530) 816-0923 Cellular

joewaterman.cpud@frontier.com

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Monday, March 23, 2015 4:38 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Info from Bailey Creek Golfcourse. - Sherrie

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Jennifer Hughes** <jennifer@baileycreek.com>
Date: Mon, Mar 23, 2015 at 11:10 AM
Subject: Re: Save Lake Almanor
To: Sherrie Thrall <sherrie.thrall@gmail.com>

Dear Sherrie Thrall,

With regards to Bailey Creek Golf Course, here is what we came up with:

We do 18,000-20,000 rounds of golf each season.
Less than 20% of our business is from the local population meaning more than 80% comes from out of the area.
What we have seen through our golf and cottage bookings, most of that 80% are here for recreational purposes in addition to golf. (Fishing, boating, hiking/walking, biking, etc)

These activities are all centered around Lake Almanor and it is a delicate balance business wise. We have a very small window to succeed. Just a 20% drop in business results in an \$300,000-\$400,000 loss. When the fires happened a couple years back, we lost the whole month of August which impacted our winter months and next year's opening greatly. Since we're seasonal due to snow, we need to make the most of our summer months so we can carry that cash through the winter months. Our bills and responsibilities never stop.
We are scheduled to open again April 10th. We have employees coming back, clubs, clothing, food and beverage stock arriving and very little cash flow to get started. We usually don't catch up until July.

I am certain that we are not the only business in the Almanor area that faces these challenges. We are family owned and operated and work very long hours to make this happen.

Please let me know if we can do anything further to help you. Thank you so much for all you're doing! I just hope they listen!

Jennifer Hughes

Bailey Creek Golf Course
433 Durkin Drive
Lake Almanor, CA 96137
Golf Shop: 530.259.GOLF
Winter Office: 530.343.PUTT
www.baileycreek.com

February 4, 2015

Wilson's Camp Prattville Resort
2932 Almanor Drive West
Canyon Dam, CA 95923

Mr. Peter Barnes, Engineering Geologist
State Water Resources Control Board
P.O. Box 2000
Sacramento, CA 95812-2000

Dear Mr. Barnes:

The purpose of this letter is to express our absolute opposition to the Water Board staff recommendation in the draft Environmental Impact Report (Federal Energy Regulatory Commission Project 2105 – Upper North Fork Feather River Hydroelectric Project). As the owners of a small, family operated resort located on the west shore of Lake Almanor (directly in Prattville by the intake tower), we can unequivocally state that the Thermal Curtain will force our business to close. We find it extremely difficult to imagine that our 87-year old business, which has survived the Great Depression, World War II, Vietnam, and countless other economic tragedies, could actually see its' demise through something as trivial as an experimental model of a Thermal Curtain. A proposed project which would take 50% of the cold water from Lake Almanor for a potentially unverifiable and unaccountable one degree temperature drop at Rock Creek/Cresta at a cost of $51 Million initial and unknown millions in maintenance cost to be funded solely by taxpayers.

Our question is, who is accountable for the loss of our income when 90% of our patrons (25,000/year) come to our resort primarily for large rainbow trout fishing? There is no doubt that the entire cold water species and habitat, not to mention other birds and mammals who feed on them, will be immensely impacted by the proposed project, if not extinct. It is important to note that Lake Almanor temperatures noted in the EIR report are 15 years old, as are the lake depth levels. At its current level, the lake is only about 25 feet deep which means that taking 50% of the lake's cold water equates to taking 100% of the cold water (based on stratification layers). The entire food web of trout, bass, salmon, catfish, perch, pond smelt, mayflies, chironomids, midges, crayfish, and so on will be thrown completely out of sync. The real uniqueness of the Lake Almanor fishery is the fact that the fish grow so large in the cold water. It is this uniqueness (large trophy fish) that has led people to visit our resort and Lake Almanor in general. There will be no going back when the projected temperature drop does not occur. The lake will die off as one of the best stillwater trophy fisheries in the United States.

Visually, the Thermal Curtain will be an eye sore as it will extend 14 acres into the lake with approximately 250 yards from our property. Many of our guest from around the world come and stay with us for this unobstructed view of Lake Almanor and Mount Lassen. When first generation, Frank Wilson, had the opportunity to purchase land on the West Shore, he specifically chose Prattville for its unmatched beauty and potential attractiveness to tourists and guests. He could have purchased almost anywhere around the lake, yet he chose Prattville, where our resort is still located 87 years later. The visual impacts of the Thermal Curtain also extend far beyond the 14 acres of its size and environmental destruction, as it would also financially impact, if not destroy, our small business with tourists and guests driven away due to its unsightliness.

The financial impacts will be catastrophic, not only to our small family business (which will not make it to our three sons, Kenneth C. Wilson, Cody T. Wilson, and Calvin M. Wilson – the fifth generation), but also to the entire county in the form of employment, payroll taxes, occupancy taxes, sales tax, etc. Tourists will seek other places to fish and recreate and ultimately, our business and many others around the lake will cease to exist. We find it hard to believe that the Water Board can recommend the degradation of Lake Almanor, which is visited by several hundred thousands of people each year as compared to the potential increase in cold water species in a location that is difficult to access and visited by probably less than a few hundred people each year. This simply does not make good sense any way it is looked at. We plead you to consider more carefully other less disruptive options to the natural environment, such as habitat restoration or Freon cooling stations downstream, as opposed to the harsh realities of an experimental idea with zero accountability. The Thermal Curtain does indeed represent "significant impact" and must be addressed as such. Without a proper cost estimate and cost-benefit analysis with updated figures, the Water Board's decision seems random, unjustified, and heartless.

Sincerely,

Carol Wilson Franchetti (Owner)
Kenneth A. Wilson Jr. and Debbie Wilson (Resort operators)
Kenneth C. Wilson
Cody Wilson
Calvin Wilson
Kenneth A. Wilson Sr. and Karen Wilson

March 21, 2015

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

Dear Sherrie Thrall:

In response to your request, Wilson's Camp grosses approximately $200,000/year and serves approximately 5,000 guest per year. While ninety percent of these guests come to our resort for the cold-water lake trout fishing, they also spend their money on local restaurants and businesses during their stay. In addition to the gross figures above, we also pay Plumas County occupancy tax of about $10,000/year. Our business will be affected the most since we are directly adjacent to the proposed Thermal Curtain site. It will negatively impact our view of Lassen, prevent boating and fishing near our resort, and be used as a dumping ground for the excavated mud, affecting overall water quality. All of the environmental issues (see our company letter in regards to the EIR report attached) affect our business from an economic impact as well.

Please put our financial concerns on file as well as a copy of our February 2015 letter send to the Water Board, as it also clarifies many economic impacts too.

Sincerely,

Ken/Debbie/Kenny/Cody/Calvin Wilson

LAKE ALMANOR BROKERS
Phone: 530-596-3303
Fax: 530-596-3330
E-mail: lakealmanorbrokers@yahoo.com
452 Peninsula Drive Lake Almanor, CA 96137
Full Service Real Estate Co.
www.LakeAlmanorBrokers.com

March 25, 2015

Dear Mr. Walter:

Thank you for discussing the findings of the SWCB Draft EIR for the North Fork Feather River hydroelectric project with me via telephone. I would like to address how important recreational fishing is to the local real estate industry. It is paramount in both property values and in the vacation rental arena.

My company currently represents over 50 homeowners in a seasonal property management program. In 2014, our vacation rental trust account had almost $950,000 run through it, in the form of rental income. Of that gross dollar amount, a 9% Transient Occupancy Tax is paid to Plumas County, which is quite a bit of revenue from just my company alone. There are at least five other local brokerages handling vacation rentals as well. Of the 1000's of tourists that occupy these homes, I would say that at least 80% of them participate in fishing at Lake Almanor in some capacity. They come here because Lake Almanor is largely considered one of the top trophy trout lakes in all of California. If the fishery is altered in any way, the tourist industry will be critically affected. The vacation rental program would be crushed and the existing real estate values would potentially suffer great losses.

Last year alone, over $60,000,000 of improved real estate was purchased in the Almanor Basin. All of these purchases were made with the thought of owning a home at a lake that has prolific trout fishing, clean lake water for recreation, and a viable economy supported by tourism. An altered Lake Almanor would severely damage the values of local real estate values.

I hope this emphasizes how vital the condition of Lake Almanor is to real estate values, property owner income, vacationing interests, local economy and Plumas County revenue. Please include my letter as an attachment if you wish. Thank you for your efforts.

Respectfully,

Jay Sabelman
Lake Almanor Brokers
530-596-3303
saborama@yahoo.com
BRE#01315308

6158 Shadowbrook Drive
Granite Bay, California 95746
cespana@surewest.net

España
Consulting
Associates

March 20, 2015

Ms Sherrie Thrall VIA EMAIL **sherrie.thrall@gmail.com**
Plumas County Supervisor
Quincy, CA

Dear Ms Thrall:

From 2000 to 2012, we rented our Lake Almanor Country Club cabin to renters during the summer. On average we rented to 10 families per year with an occupancy limit of 8 persons per week.

In discussions with renters, invariably they listed boating and fishing as their two primary reasons for renting in Lake Almanor. We had several repeat annual renters who taught their children how to fish during their first visit and kept up the annual tradition of fishing in subsequent years.

The draw of Lake Almanor to visitors is varied but for most families it centers on traditions like fishing and boating.

Sincerely,

Carlos España
Owner
1304 Peninsula Drive
Lake Almanor, CA 96137
916-416-7970

Walter, Hanspeter

From:	Sherrie Thrall <sherrie.thrall@gmail.com>
Sent:	Monday, March 23, 2015 5:12 PM
To:	Walter, Hanspeter
Subject:	Fwd: Save Lake Almanor

This from one of our smaller resorts on the east shore. - Sherrie

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Rob Hart** <rob@womackent.com>
Date: Fri, Mar 20, 2015 at 6:47 AM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

Knotty Pine and Rooms at 412 have approximately 650 visitors and about 60 % come to fish.

Rob Hart
Knotty Pine Resort

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Monday, March 23, 2015 5:14 PM
To: Walter, Hanspeter
Subject: Fwd: Thermal Curtain at Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Kim Jergentz** <kimjergentz@yahoo.com>
Date: Mon, Mar 23, 2015 at 5:12 PM
Subject: Thermal Curtain at Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Hello Ms. Thrall:

I read the article in the Progressive this weekend and wanted to comment about the prospect of this thermal curtain actually happening to the basin.
I am a homeowner on the Peninsula, I rent my property during the "peak season" and I am a real estate agent with Coldwell Banker DuFour Realty in Chico, Ca. I grew up in Chester and I have an extreme fondness for the area, the Lake and all it has to offer. Being from Chester I am keenly aware of the economic impacts that the town has endured over the course of the last 20 yrs. Collins Pine WAS the main employer, Stover Mountain WAS a local ski destination and Seneca Hospital WAS one of the best facilities in the area. As you are aware, NONE of these conditions exist today therefore causing the local Business Community to try to reinvent the area as a sports fishing/recreation/snow mobile area for year round enjoyment. The Chamber has spent tireless hours marketing the area all over the State including the Bay Area and the Reno/Tahoe areas as well.
This effort seems to be working as many of my renters come from the Reno or Bay areas and come back year after year to enjoy the Lake and all the amenities. My pool of renters are REPEAT people who rent every year, usually the same time of the year --- and they call me, not the other way around.
If this thermal curtain happens then it will ruin the town and it's ability to maintain any type of status as a premier recreation area. The immediate effect it will have on the real estate is hard to determine: except the real truth is it will render most of the Lake front properties virtually worthless --- , inventory will be at an all time high and people (like me) who have owned their properties for years and hoped to pass it along to their children wouldn't have anything of value to leave them. All I can think of is ClearLake.............and there's nothing Clear about that Lake !! The algae blooms, the "greenish" color of the water and the lack of native fish/birds/other wildlife will be devastating to the entire basin.
Please don't let this happen................

Most sincerely,

Kim Jergentz

Kim Jergentz
KimJergentz@yahoo.com

Direct: (530) 896-3157
Office: (530) 895-1545
Cell: (530) 520-6618
FAX: (530) 343-8233

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Monday, March 23, 2015 5:17 PM
To: Walter, Hanspeter
Subject: Fwd: Economic Impact of Thermal Curtain on my restaurants

This from one of the most successful resort/restaurant owners in the area.

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **carol** <carolscafe1@earthlink.net>
Date: Thu, Mar 12, 2015 at 2:26 PM
Subject: Economic Impact of Thermal Curtain on my restaurants
To: Sherrie <sherrie.thrall@gmail.com>

Dear Sherrie, I received your request for information regarding what would happen to my business if the thermal curtain is built. As you know, our family resort will be most impacted as we are the closest to the proposed curtain.
Last year, my restaurant in Prattville grossed $235,860. We served over 25,000 guests and of that number, about 30% are full time residents of the area. If the thermal curtain goes through, I would have to shut down as about 70% of my guests are here for the fishing or boating. With no view, the locals would not come either. With the few people left, I could not earn enough to pay liability insurance, payroll taxes, or workman's comp. It would be a sad end to the 44 years I have spent at Prattville providing food for guests and payroll to the Lake Almanor area.

My Chester restaurant is open year around and have a larger percentage of local business. However, sales are extremely slow in the winter and I would say that business from out of the area here to fish and recreate is about 50%. My sales for last year were $217,123.

Lastly, you did not ask but I think it is vitally important, $197,990 in gross payroll went out into the community. They spent their dollars at local grocery stores, gas stations, restaurants, and bars. If I close down, 17 to 25 people will be out of work, most of whom have children.

These figures do not reflect Kenny's income for the campground. He will be sending it to you separately. Thanks so much for doing all you can to head off this grievous injustice to our beautiful Lake Almanor. Sincerely, Carol Franchetti

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:42 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor Letter on Visitors Fishing
Attachments: Espana thermal 0218.pdf

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Carlos Espana** <cespana1304@gmail.com>
Date: Sat, Mar 21, 2015 at 5:39 PM
Subject: Save Lake Almanor Letter on Visitors Fishing
To: sherrie.thrall@gmail.com

Attached is my letter documenting visitors preferring fishing as part of their vacations at Lake Almanor.

I didn't exactly state a % in the letter but I would estimate it at 80 percent for the 80 renters we had per year.

Best of Luck

--
Carlos' Home Email

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:41 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **lewis campbell** <soupfin@gmail.com>
Date: Sat, Mar 21, 2015 at 3:54 PM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

This is in response to your request for the number of visitors we have who fish. I have been coming to the Chester area since 1948 (66 yrs.) and have been a property owner in LACC since 1992. We normally spend about six months each year at our home up there. I would estimate my time fishing from a boat and shore about 40%. Regularly we have about 10-12 visitors per year 75% of whom fish. I realize our numbers are not huge but I feel compelled to help halt the installation of the " thermal curtain ". Thanks for the opportunity to participate.
Clifford King

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:41 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **markhscott** <markhscott@yahoo.com>
Date: Sat, Mar 21, 2015 at 8:20 AM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

Hello, we have approximately 30 visitors a year, who all come to Lake Almanor to fish. Thanks, Mark Scott

Sent via the Samsung GALAXY S® 5, an AT&T 4G LTE smartphone

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:40 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Rob Hart** <rob@womackent.com>
Date: Fri, Mar 20, 2015 at 6:47 AM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

Knotty Pine and Rooms at 412 have approximately 650 visitors and about 60 % come to fish.

Rob Hart
Knotty Pine Resort

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:39 PM
To: Walter, Hanspeter
Subject: Fwd: thermal curtain

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Jim Newell** <jim@intermountainenterprises.com>
Date: Thu, Mar 19, 2015 at 2:24 PM
Subject: thermal curtain
To: sherrie.thrall@gmail.com

I am the CFO of intermpuntain Emterprises, LLC. We have two businesses in Chester that will be wconocally effected drastically by the thermal curtain, Intermountain Hardware & Supply and Chester Paint Centet. The two businesses are located in the Historic Ayoob's building which has been doing business continually since 1946.

We sell fishing licenses, bait and equipment. We could suffer a $250,000 loss in business just in the sporting goods department.

People buy paint to keep their rental investment properties looking good.

Last year we had $1,254,000 is sales. We could lose half of that which would cause us to go bankrupt. Five families derive aiving from our company they wouldn't be put out of work.

This needs to be stopped at all costs

--
Jim Newell
Vice President & CFO
Intermountain Enterprises, LLC
Cell 530-515-1896

Walter, Hanspeter

From: Sharon Thrall <sherrie.thrall@gmail.com>
Sent: Wednesday, March 25, 2015 5:57 PM
To: Walter, Hanspeter
Subject: Fwd: Follow-up letter written earlier.

Copy of letter written by local business owner.

Sharon (Sherrie) Thrall
Supervisor, District 3
PLUMAS COUNTY

Sent from my iPad

Begin forwarded message:

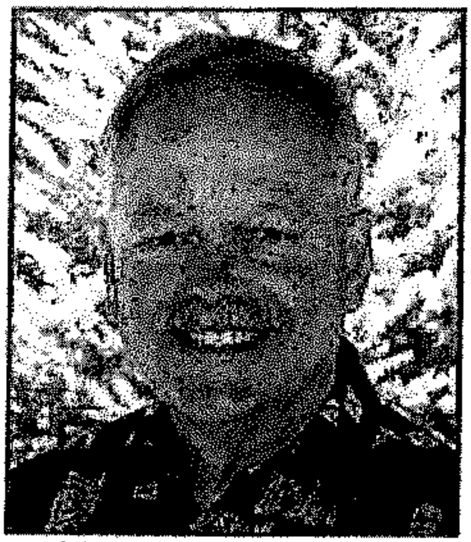
> **From:** Ron Martin <ronmartin@ronmartinrealty.com>
> **Date:** March 25, 2015 at 4:56:29 PM PDT
> **To:** <Peter.Barnes@waterboards.ca.gov>, <sherrie.thrall@almanorpost.com>
> **Subject: Follow-up letter written earlier.**
>
> Dear Board Members,
>
> I neglected to mention in my previous email that I have been selling real estate in the Lake Almanor Basin for the last 36 years and manage vacation rental properties producing revenues to property owners and to Plumas County to the tune of $300,000 gross revenues annually benefiting the County of Plumas by $27,000 annually in TOT (Transient Occupancy Taxes) or 9% of the gross revenues. We also own and R.V. Park and provide additional revenues to the county from that, plus we own a Lodge which produces more income plus my Real Estate Office producing $5,000 to $10,000 annually to the county for documentary transfer taxes paid. All 4 of these businesses are 95% supported by fishermen and women and vacationers. If the Thermal Curtains are put into place, all 4 of my businesses would be wiped out and I would be forced to leave the area and close my businesses.
>
> That is the reason that I have such a major interest and concern about the demise of Lake Almanor. I have sold most of the small businesses in the area over the last 36 years and I can tell you that none of them would survive if Lake Almanor was ruined. These include gas stations, restaurants, shops, convenience stores, resorts. This does not even mention the devastation to property values. If there were no Lake Almanor for recreation and may I say that it is the best in the West and arguably the best anywhere all the properties would be valueless and the area blighted.
>
> Another major consideration of any negative experimental modification as to the Lake water quality would have a ripple effect all the way to Los Angeles and everywhere in between. Lake Almanor being the headwaters of the Feather River Project and the California Aqueduct. With pollution in the headwaters, how will that affect the water quality in Oroville and Los Angeles? That project was completed in 1969 I believe.

Rights to the management of the water in Lake Almanor were granted to the Great Western Power Company in 1979 for power production by the Federal Government in 1917, Guy Earl was the president at the time and the lake was named after his 3 daughters Alice, Martha and Eleanor thus AlMaNor or Almanor. Those rights were sold subsequently to PG&E under a leasing agreement with the oversight of FERC. Any requirements made on PG&E by the State requiring profound revenues is austensibly a tax on the residence of the state if PG&E is allowed to raise their rate schedule (unfair taxation). Please don't allow any undue "tax" to increase profits for PG&E or undue modification to our lake!

Any modification to Lake Almanor should be CAREFULLY considered for the protection of the entire State and any representative of the people has a fiduciary responsibility of this utmost care! Please be that careful and don't take unnecessary risks with our and our children's and grand children's future.

Sincerely,

Ron Martin



Ron Martin
Owner/Broker
DRE# 00621084

RonMartin REALTY
317 Main St. | PO Box 1099 | Chester, CA 96020
530-258-3000 Office
800-444-8004 Toll Free
530-258-4160 Fax
530-258-1400 Cell
E-mail: RonMartin@RonMartinRealty.com
Website: www.RonMartinRealty.com

Visit Us At The Time And Temp Sign
Don't Miss Our Live Chester Cam Online

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:36 PM
To: Walter, Hanspeter
Subject: Fwd: Curtain Economic Impacts

This is a huge issue with our local realtors. They feel the need to disclose the potential adverse impacts of the SWRCB actions relative to 2105. They tell me this is causing potential buyers to rethink their position.

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Bridget Johnston** <biddyj@aol.com>
Date: Wed, Mar 18, 2015 at 4:41 PM
Subject: Curtain Economic Impacts
To: sherrie.thrall@gmail.com

Hi, Sherrie.

Saw your request for info on potential economic impacts of the thermal curtain on the surrounding Lake Almanor communities and thought of an impact mentioned during the last go round of this curtain fiasco that I haven't seen mentioned this time:

The realtor's association stated then that they were having to disclose the possibility of a thermal curtain to potential buyers as a known negative about Almanor properties.

Perhaps Wendy would have more on this.

Go get 'em!

Bridie Johnston

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:33 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **JUDY MAAS** <jsjemaas@msn.com>
Date: Wed, Mar 18, 2015 at 2:05 PM
Subject: Save Lake Almanor
To: "Sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Sherrie,
Thank you for your efforts to save Lake Almanor.
Here's my family's impact on the Lake Almanor community:

My family represents those who travel to Plumas County annually to vacation. We have done so for over 50 years. We have our two weeks reserved for a home on Lake Almanor and are looking forward to July.

Every year we have left several thousand dollars in the communities around Lake Almanor, from Greenville to Westwood to Quincy. We give to Holiday Market, Peninsula Market, Lassen Drug Store, Ace Hardware, restaurants in Prattville, Chester, Lake Almanor peninsula, the gas stations, Bailey Creek golf course, LACC golf course, Lake Almanor West golf course, the shops and galleries in Chester, the Chester Library through their book sale. We've rented boats and bikes.
We've donated to churches, the Fireworks campaign, and Seneca Hospital.
And we're about to help save the Olson Barn.

We are happy to contribute to a county that has given our family many, many enjoyable experiences.
And we hope that Lake Almanor is saved so that we can continue our annual trip.

Sincerely,
Judy and John Maas
Salem, Oregon

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:32 PM
To: Walter, Hanspeter
Subject: Fwd: Lake Almanor economic impact letter

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Jane Janssen** <janej777@sbcglobal.net>
Date: Tue, Mar 17, 2015 at 7:15 PM
Subject: Lake Almanor economic impact letter
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

To Sherrie Thrall: Thank you for your concern about our beautiful lake. Here is my letter:

March 17, 2015

Hal Janssen
687 Peninsula Dr.
Lake Almanor, CA

Plumas County Supervisor
Sherrie Thrall

To All it may concern:

I a professional fly fisherman, I am not a guide, I am an instructor. Lake Almanor is large part of my livelihood. I have about 100 visitors a year to Lake Almanor, 100% of my quests come for the purpose of fishing Lake Almanor, Butte Valley Reservoir and the surrounding areas. Many of the people I instruct rent homes, camp sites or hotel rooms, they shop at the grocery stores, gift shops, eat at the local restaurants. Frequently I see them return to the lake with additional friends or family members. The town of Chester's economy thrives on tourism. Lake Almanor is the major factor in bringing visitors to the area. Without the cool clear water, the algae bloom would destroy the organisms in the lake, most of the fish species would die as a result. The town of Chester and the surrounding areas will then suffer a huge economic loss.

Thank You for your attention to the health of our Lake
Hal Janssen

Walter, Hanspeter

From:	Sherrie Thrall <sherrie.thrall@gmail.com>
Sent:	Tuesday, March 24, 2015 1:32 PM
To:	Walter, Hanspeter
Subject:	Fwd: Visiting Lale Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: <jjaitken@comcast.net>
Date: Tue, Mar 17, 2015 at 5:54 PM
Subject: Visiting Lale Almanor
To: sherrie thrall <sherrie.thrall@gmail.com>

Sherrie Thrall,
We applaud your efforts to Save Lake Almanor. Our family of 10 plus friends have been enjoying the diverse activities offered by the lake including fishing for over 40 years. We usually stay for 2 to 3 weeks in various homes which form the base camp for our summer vacation. We view any major changes such as the Thermal Curtain as a major negative which could impact the enjoyment of our traditional vacation.

Let us know if there is anything we can do to support your efforts.

Last year we obtained a projection of the lake elevation for July and August. Are you aware of such a projection for this year?

Thanks for your support.

Jack and Joan Aitken

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:30 PM
To: Walter, Hanspeter
Subject: Fwd: Opposed to Water Board EIR - Lake Almanor, CA

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Caryn Schulman** <ckschulman@att.net>
Date: Fri, Mar 20, 2015 at 2:26 PM
Subject: Opposed to Water Board EIR - Lake Almanor, CA
To: "peter.barnes@waterboards.ca.gov" <peter.barnes@waterboards.ca.gov>
Cc: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Mr. Peter Barnes,

I am a homeowner in Lake Almanor California and I am deeply saddened by the State Water Board staff's recommendation in the draft EIR to construct THERMAL CURTAINS at Prattville in Lake Almanor and Caribou intake at Butte Valley Reservoir. I have read numerous articles about the proposed plans and I am appalled to hear that the "Only" significant impact would be to the Aesthetics! I know these plans would have a severe impact to the Lake Almanor environment and destroy our beautiful lake. Why does it make sense to wreck one environment to TRY to make another one better? The State Water Resources Control Board has used outdated science, poor analysis and bad judgment. It just doesn't make any sense and I am in complete opposition to the draft EIR.

Please do not continue on with the recommendations in the draft EIR. This would ruin our way of life and the beautiful place we call paradise!!

Most Sincerely,

Caryn Schulman
544 Ponderosa Drive
Lake Almanor, CA 96137
ckschulman@att.net
(530) 596.6284

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:29 PM
To: Walter, Hanspeter
Subject: Fwd: Fishing visitors

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Bruce Brown** <bhbrown1@juno.com>
Date: Fri, Mar 20, 2015 at 11:46 AM
Subject: Fishing visitors
To: sherrie.thrall@gmail.com

Sherrie,

We have at least 25 visitors per year who come to fish.

Bruce Brown

1339 Lassen View Dr. LACC

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:12 PM
To: Walter, Hanspeter
Subject: Fwd: visitors

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Deborah Ebert** <ebert5@aol.com>
Date: Thu, Mar 12, 2015 at 6:24 PM
Subject: visitors
To: sherrie.thrall@gmail.com

Hello Sherrie,

We have 30 visitors a year and 25 fish.

We also have a family tradition where some members of our family swim across the lake from the Point to Camp Pratville. One year, there was an algae bloom and our swimmers were covered in green slim by the time they arrived. They said they would never do it again, and they haven't. It is sad. It was late August, the water was warm and algae came out.

Best Regards,
Deborah Stewart Ebert
1427 Peninsula Drive

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:12 PM
To: Walter, Hanspeter
Subject: Fwd: visitors

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Leonard and Marsha Kaiser** <lmkaiser2@yahoo.com>
Date: Thu, Mar 12, 2015 at 5:41 PM
Subject: visitors
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Hello
We have a house on Lake Almanor that we rent out and also let friends stay at. There may be 15 fishermen a year that stay there.
That does not count other family members.
I will try and send you a email I just sent to Mr Barnes at the Water Board.
Hope this helps Leonard Kaiser

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:11 PM
To: Walter, Hanspeter
Subject: Fwd: Visitors to Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Donna Fields** <dfieldsenvoy@hotmail.com>
Date: Thu, Mar 12, 2015 at 5:12 PM
Subject: Visitors to Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

We are part time residents and have numerous visitors up to fish. Our visitors come to fish, that is what this lake is all about. The young ones water ski, wake board, etc., but the adults are here primarily to fish. We have on average twelve different families up on a regular basis and 100% of them fish. They, as do we, help support our local community buying groceries, gas, fishing equipment, and of course eating out everyday for at least one meal.
Thank you,
Rick and Donna Fields
1422 Peninsula Dr.
Lake Almanor, CA 96137
916 316-4120

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:10 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Thenut** <thenut@citlink.net>
Date: Thu, Mar 12, 2015 at 5:00 PM
Subject: Save Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Hi Sherrie - At The Sports Nut most of our sales are in fishing equipment and t-shirts (lot of them with fishing themes). I would say about 90% of our business would be affected.
We will be returning home on March 24th from Mexico - if we need to send this info in a letter form. Thanks for all your work. It's appreciated. Let me know what else we can do?
Thanks again
Kathy

Sent from my iPhone
Kathy

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:09 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Dennis** <denpam@aol.com>
Date: Thu, Mar 12, 2015 at 4:44 PM
Subject: Save Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

We have at least 50 guests each year and they all fish the lake and the streams.

I'm sure the proponents of this scheme know the outcome of the cold water releases. Just look at the the lakes and streams that this has happened to by other means.
I thought we as a state were long over this nonsense. Ruining one ecosystem to POSSIBLY restore another? Irresponsible!

I'm afraid only litigation will help us. Good luck and thank you for your efforts.

Dennis Welsh
831 E. Mountain Ridge

Sent from my iPad

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:08 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Diana Costales** <dcostales.cbl@gmail.com>
Date: Thu, Mar 12, 2015 at 4:31 PM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

Sherrie,

I have approximately 100 visitors per yr. About 75% come here to fish. ALL come to use the lake, swim or boat.

My family has been vacationing at Lake Almanor for over 50 yrs...and have owned a home there for over 40 yrs.

Good luck with this battle. I live in NM so I'm able to give my support in person.

Diana Costales
Cell: 505 363-5457
DCostales.CBL@gmail.com
Associate Broker
Coldwell Banker Legacy
500 Unser #101
Rio Rancho, NM 87124
Office: 505 892-1000
EFAX: 505 468-0911

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:08 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Peter Righero** <pm6483@att.net>
Date: Thu, Mar 12, 2015 at 4:12 PM
Subject: Save Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Sherrie. Although I am just a home owner on the peninsula I do come up to lake Almanor just to fish on certain weekends. I spend approx 20-25 days on Almanor throughout the year. If our fishery was impacted I would come up much less in the fall winter and spring. This is the time of the year when our local business need visitors

Peter Righero

Sent from my iPhone

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:07 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Linda Brown** <linbrown@sbcglobal.net>
Date: Thu, Mar 12, 2015 at 4:09 PM
Subject: Save Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Hi Sherrie,
We have approximately 25 guest a summer and I would say 90% come to fish.
Linda Brown
1232 Lassen View Dr.

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:07 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Muffy Bui** <muffybui@pacbell.net>
Date: Thu, Mar 12, 2015 at 3:45 PM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

Dear Sherrie,

We have at least 35 visitors during the summer and of that number I would say about 75% come to fish the lake. Also, after a day on the lake we go out to dinner with our guests and support the local economy.

Sincerely,

Doug and Muffy Bui
1335 Lassen View Dr
Lake Almanor

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:06 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Dennis Mason** <dmasonrealtor@gmail.com>
Date: Thu, Mar 12, 2015 at 3:31 PM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

Sherrie,

I had 377 visitors and renters, about 94% come to fish. The Water Boards options will ruin our lake.

ALMANOR PROPERTIES, INC.

Dennis Mason CRB, GRI
CAR Director for Life
Almanor Properties, Inc.
Broker/Owner #00619354
313 Peninsula Drive
Lake Almanor, CA 96137
(530)596-3232 Office
(530)251-7711 Cell
(530)596-3234 Fax
dmasonrealtor@gmail.com
www.almanorproperties.com

PLEASE NOTE: MY NEW EMAIL ADDRESS DMASONREALTOR@GMAIL.COM -- I WILL NO LONGER BE USING DMASON@THEGRID.NET.

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:06 PM
To: Walter, Hanspeter
Subject: Fwd: Lake visitors that fish (Bill Light -LACC)

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: <lighthouse49@comcast.net>
Date: Thu, Mar 12, 2015 at 3:12 PM
Subject: Lake visitors that fish (Bill Light -LACC)
To: sherrie.thrall@gmail.com

Mrs. Thrall, I have approximately, 25 visitors all of whom fish when they come to visit (family and friends), so 100% !!!!!!
Bill Light --817 East Mountain Ridge Road, Lake Almanor, Ca 707-373-2265 Thank you for your support on this extremely serious matter.

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:05 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Konnie Marskey** <madronechico@gmail.com>
Date: Thu, Mar 12, 2015 at 3:11 PM
Subject: Save Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Hi, I would estimate that we rent or give out our cabin at Lake Almanor West about 42 days a year. I would guess about half of the people fish.
We are in support of keeping the Lake as it is.
Thank you for your efforts, KONNIE Marskey

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:05 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Reynolds, James E (GE, Measurement & Control)** <james1.reynolds@ge.com>
Date: Thu, Mar 12, 2015 at 3:09 PM
Subject: Save Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

I have about50 visitors per year and 40% fish.

James E. Reynolds, PE | Senior Service Manager
GE Oil & Gas
T +1 775 677 7664
M +1 775 721 3765
E james1.reynolds@ge.com

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:04 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Dan Van Elderen** <danvan16@comcast.net>
Date: Thu, Mar 12, 2015 at 3:01 PM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

Hi Sherrie,

I am an owner/resident of two homes at 1210 Peninsula Dr. and 1212 Peninsula at Lake Almanor. We typically have between 75 - 100 guests that visit us each year at Lake Almanor, and I'd estimate that about 75% of them come to fish the lake. I also personally myself fish the lake almost daily.

I am very concerned about the impact that the proposed cold water extraction from Lake Almanor would have on the Lake Almanor environment, and in particular the lake's fish habitat, their food supply, and their long-term survival rate.

Best Regards,
Dan Van Elderen
(530)259-4103

Walter, Hanspeter

From:	Sherrie Thrall <sherrie.thrall@gmail.com>
Sent:	Tuesday, March 24, 2015 1:00 PM
To:	Walter, Hanspeter
Subject:	Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: <skmcfarren@comcast.net>
Date: Thu, Mar 12, 2015 at 2:41 PM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

Hi Sherrie.
Thanks for taking this on and helping to protect the most beautiful lake in Northern California!

We typically have 25 visitors a year at our cabin, and 12% of these visitors fish. We all swim, boat, and enjoy the lake.

Kathleen McFarren
1111 Fairway Pines Road
LACC

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 1:00 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Garn Pringle** <lakealmanorfitness@yahoo.com>
Date: Thu, Mar 12, 2015 at 2:29 PM
Subject: Save Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Lake Almanor Fitness Center have approximately 100- 125 visitors per month between mid April to mid October who use our fitness facility while they are camping and fishing on Lake Almanor.
Garn Pringle
General Operations Manager

Sent from Garn Pringle's iPhone

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 12:58 PM
To: Walter, Hanspeter
Subject: Fwd: Economic Impact of Thermal Curtain on my restaurants

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **carol** <carolscafe1@earthlink.net>
Date: Thu, Mar 12, 2015 at 2:26 PM
Subject: Economic Impact of Thermal Curtain on my restaurants
To: Sherrie <sherrie.thrall@gmail.com>

Dear Sherrie, I received your request for information regarding what would happen to my business if the thermal curtain is built. As you know, our family resort will be most impacted as we are the closest to the proposed curtain.
Last year, my restaurant in Prattville grossed $235,860. We served over 25,000 guests and of that number, about 30% are full time residents of the area. If the thermal curtain goes through, I would have to shut down as about 70% of my guests are here for the fishing or boating. With no view, the locals would not come either. With the few people left, I could not earn enough to pay liability insurance, payroll taxes, or workman's comp. It would be a sad end to the 44 years I have spent at Prattville providing food for guests and payroll to the Lake Almanor area.

My Chester restaurant is open year around and have a larger percentage of local business. However, sales are extremely slow in the winter and I would say that business from out of the area here to fish and recreate is about 50%. My sales for last year were $217,123.

Lastly, you did not ask but I think it is vitally important, $197,990 in gross payroll went out into the community. They spent their dollars at local grocery stores, gas stations, restaurants, and bars. If I close down, 17 to 25 people will be out of work, most of whom have children.

These figures do not reflect Kenny's income for the campground. He will be sending it to you separately. Thanks so much for doing all you can to head off this grievous injustice to our beautiful Lake Almanor. Sincerely, Carol Franchetti

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 12:58 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: <Corneliussen@aol.com>
Date: Thu, Mar 12, 2015 at 2:20 PM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

Dear Sherrie,

I am a home owner in the Lake Almanor Country Club and we host been 30-40 people each season of whom 80% come to fish in the lake.

We appreciate your efforts in saving our beautiful lake.

Best regards,

Torben Corneliussen
1111 Lake Ridge Road
Lake Almanor, CA.
707 291 2995

Walter, Hanspeter

From:	Sherrie Thrall <sherrie.thrall@gmail.com>
Sent:	Tuesday, March 24, 2015 12:58 PM
To:	Walter, Hanspeter
Subject:	Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Robbyn McDowell** <Robbyn.McDowell@earnhardt.com>
Date: Thu, Mar 12, 2015 at 1:57 PM
Subject: Save Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

We have approximately 30 visitors a year to Lake Almanor and they all fish!!!!

Robbyn McDowell

CFO Earnhardt Management Company

480-783-4620 - office

602-291-9923 - cell

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 12:57 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Katie DeLucchi** <jpdeluc@aol.com>
Date: Thu, Mar 12, 2015 at 1:54 PM
Subject: Save Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Hi Sherri,
We don't rent out place, but of the people who have visited, 30% of our friends used the lake for fishing. Everyone I talk to who actually knows where Lake Almanor is (I live in the South Bay) only know it because of the great fishing!
Hope this helps
Katie DeLucchi

Sent from my iPhone, witch doe snot properly cork rect my typos.

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 12:48 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Cliff and Lynne** <ctslms@aol.com>
Date: Thu, Mar 12, 2015 at 11:08 AM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

Sherrie, we have either visited, owned property, or lived permanently at Lake Almanor since 1974. Our family owned the store at Canyon Dam in years immediately following WWII.
Although our numbers are small when compared to those provided by commercial establishments, we are in hopes that others with residential visitors will also respond and that collectively we can make a difference. Annually, we average approximately 23 visitors per year. Of these, approximately 6 visit multiple times. Of the 23, 19 enjoy fishing. More importantly, all 23 participate in water sports. For the last two years, the areas that our guests could utilize for water sports have been reduced in size and in number due to the increase in algae bloom that brings with it the parasite known as "Swimmers Itch". Any increase in lake temperature due to cold water draw down, either by the curtain or by deep water outfall at the dam, will only serve to exacerbate the problem. If it worsens, they will most certainly seek other venues for their activities rather than continue to expose their families to the parasite. Nearby, Clear Lake is a prime example of the devastation caused by the increase in algae that can reduce visitors, decrease property values and destroy tourism.

Respectfully,
Cliff and Lynne Shelton

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 12:47 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Judi** <lakehavenllc@gmail.com>
Date: Thu, Mar 12, 2015 at 10:36 AM
Subject: Save Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Hi
First of all I would like to thank you for doing this for your community and please know it is appreciated.
We provide lodging for anywhere between 400 to 600 people per year. I would have to estimate that 90% of the business we get is dependent upon the fishery here in like Almanor. If there's any other information you need or anything else you need I would be happy to provide it please let me know.

Thank you,
Judith Finkbeiner
Lake Haven Resort

Come and enjoy the best of what Lake Almanor has to offer!

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 12:47 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Marcia** <pacificgal101@msn.com>
Date: Thu, Mar 12, 2015 at 10:20 AM
Subject: Save Lake Almanor
To: sherrie.thrall@gmail.com

Sherrie,

I received a message from the Better Bussing so Bureau. I personally have about 20 guest that come to Lake Almanor basin every year and 100% of them come to fish. This is nor many but I hope it helps. We need to keep Lake Almanor fusing viable.

Marcia Stallworth
Real Estate Broker

Sent from my Verizon Wireless 4G LTE smartphone

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 12:46 PM
To: Walter, Hanspeter
Subject: Fwd: Save Lake Almanor

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Cliff Fahey** <cgfahey@yahoo.com>
Date: Thu, Mar 12, 2015 at 10:04 AM
Subject: Save Lake Almanor
To: "sherrie.thrall@gmail.com" <sherrie.thrall@gmail.com>

Hey Sherrie,

We have met in t the past -- current home owner in the LACC

www.longshootlodge.com

We Book our place out at least 5 months a year -- this coming year it looks to be closer to 6 months -- even in the winter months.

We have at least 6 repeat renters that come form NV, OR, and SoCAL for the last 4 years for the fishing on the lake. The Balance of our renter come for the Lake - both fishing and water sports. If the lake is damaged from the current state - we will need to sell the property and would no longer come to the area.

We depend on the rental income to upgrade the property - investing about 10K per year in property improvement. In addition, we provided local residents part time jobs - from house cleaning, yard maintenance, electrical, plumbers and construction workers.

The Lake is the draw for our renters - without the fishing our income would drop.

There are alternatives to the thermal curtain that need to be pursued as the solution - some are much more "green" by planting trees to shade the Feather River.

Thanks for hearing my voice.

Cliff Fahey
Thomas Greely MD

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Tuesday, March 24, 2015 12:46 PM
To: Walter, Hanspeter
Subject: Fwd: visitors

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: <karinur@comcast.net>
Date: Thu, Mar 12, 2015 at 10:02 AM
Subject: visitors
To: sherrie.thrall@gmail.com

We rent our home out at 600 Cedar Canyon Road. It accommodates 16 and is rented for a least 8 weeks. That means at least 128 visitors of which I am sure 80 to 85 percent fish Lake Almanor. I sent my comments to the water board last month along with support of the official LACC letter. Best of Luck to us all!

Karin Urquhart

Walter, Hanspeter

From: Sherrie Thrall <sherrie.thrall@gmail.com>
Sent: Wednesday, March 25, 2015 11:35 AM
To: Walter, Hanspeter
Subject: Fwd: rental

Hi, here is one more from a local realtor.

Sharon (Sherrie) Thrall
Plumas County Supervisor, District 3
P.O. Box 368
Chester, CA 96020
530-258-3656
website: almanorpost.com

---------- Forwarded message ----------
From: **Wendi Durkin** <wendi@bhhslakealmanor.com>
Date: Tue, Mar 24, 2015 at 10:57 AM
Subject: rental
To: Sherrie Thrall <sherrie.thrall@gmail.com>

Sherrie, I ran the numbers as we discussed. I have a spreadsheet I can send outlining the below. Is this what you want for Hanspeter? Please let me know. Thanks!

I currently manage 39 vacation rental homes in the Lake Almanor Basin. In order to determine if cold water removal would affect my revenue as well as my clients, I did some number crunching.

Our main cliental for May, early June, September and October are fishing people. So, I used an 80% revenue split for those months. During peak season which is late June, July, August, I assumed those people were mostly vacationing and probably fished as a part of their vacation, but not with the same intensity. So, I used a 20% split.

It was determined that the income my business would lose is approximately $59,000. Between my 39 homes, the owners could lose as much as $480,000 in revenue. For the Water Board to say the economic impact is less than significant is just untrue. Maybe those numbers don't matter to them, but I assure you they matter to me and my clients.

Regards,

Wendi Durkin

Wendi Durkin

Broker Owner

Berkshire Hathaway HomeServices Lake Almanor Real Estate

BRE#01194091

Office 530-259-5687

Fax 530-259-4750

Cell 530-228-2683

ATTACHMENT 11

California Gap Analysis Project's Predicted Distribution Map

Mountain Yellow-legged Frog *(Rana muscosa)*

Metadata **(Data about data or how the map was made)**

Legend:
= Core Habitat

Predicted Distribution
The purpose of the vertebrate distribution maps is to provide more precise information about the current distribution of individual native species within their general ranges than is generally available from field guides.

Amphibians do not migrate as some birds and mammals, so the colored areas depict the predicted range for the Mountain Yellow-legged Frog year-round. The habitats were identified using satellite imagery, other datasets and experts throughout the state, as part of the California Gap Analysis Project.

Webpage designed by Dave Lester

California Gap Analysis Project's Predicted Distribution Map

Cascades Frog *(Rana cascadae)*

Metadata (Data about data or how the map was made)

Legend:
☐ = Core Habitat

Predicted Distribution
The purpose of the vertebrate distribution maps is to provide more precise information about the current distribution of individual native species within their general ranges than is generally available from field guides.

Amphibians do not migrate as some birds and mammals, so the colored areas depict the predicted range for the Cascades Frog year-round. The habitats were identified using satellite imagery, other datasets and experts throughout the state, as part of the California Gap Analysis Project.

Webpage designed by Dave Lester

California Gap Analysis Project's Predicted Distribution Map

Foothill Yellow-legged Frog *(Rana boylii)*

Metadata **(Data about data or how the map was made)**

Legend:
☐ = Core Habitat

Predicted Distribution
The purpose of the vertebrate distribution maps is to provide more precise information about the current distribution of individual native species within their general ranges than is generally available from field guides.

Amphibians do not migrate as some birds and mammals, so the colored areas depict the predicted range for the Foothill Yellow-legged Frog year-round. The habitats were identified using satellite imagery, other datasets and experts throughout the state, as part of the California Gap Analysis Project.

Webpage designed by Dave Lester

California Gap Analysis Project's Predicted Distribution Map

California Newt *(Taricha torosa)*

Metadata **(Data about data or how the map was made)**

Legend:
☐ = Core Habitat

Predicted Distribution
The purpose of the vertebrate distribution maps is to provide more precise information about the current distribution of individual native species within their general ranges than is generally available from field guides.

Amphibians do not migrate as some birds and mammals, so the colored areas depict the predicted range for the California Newt year-round. The habitats were identified using satellite imagery, other datasets and experts throughout the state, as part of the California Gap Analysis Project.

Webpage designed by Dave Lester

ATTACHMENT 12

PERMIT TO MINE / RECLAMATION PLAN

PERMITTEE: Seneca Gold, LLC

OWNER: Estate of Lee Crowe – David & Lorrie Preim

DATE APPROVED: July 16, 2014

USE PERMITTED: Surface placer gold mining.

ASSESSOR'S PARCEL NUMBER: 002-280-002

LOCATION: 587 Little Seneca Road, Canyon Dam. T.26N/R.8E/S.9 MDM

Permittee is hereby granted a Permit to Mine / Reclamation Plan under the provisions of Plumas County Code Sections 9-5.01 *et seq.*, subject to the following conditions:

1. The initiation date for the Permit to Mine/Reclamation Plan will be the date of signature of the permit by the Applicant/Operator.

2. The Permit to Mine/Reclamation Plan will expire August 2024, unless an extension of time is granted. Activities related to reclamation of the site may extend past this date as necessary to complete reclamation per the approved plan, except that no further mining activity shall be started after the expiration date.

3. The Permit to Mine/Reclamation Plan shall be conducted in compliance with the plan and plan maps submitted in the ***Surface Mining and Reclamation Plan for Seneca Mine, Mineral Patent CA 30606, Plumas County, CA,*** **prepared for Seneca Gold, LLC, by Holdrege & Kull,** unless modified by the following conditions.

4. Mining, processing and a significant part of reclamation activities shall take place during April 1st through October 31st of each year.

5. Pursuant to California Department of Fish and Wildlife requirements, no suction dredging is to be performed within 100 yards of the North Fork Feather River. No possession of a suction dredge is allowed within 100 yards of the North Fork Feather River.

6. A Hazardous Materials Business Plan for fuel and/or petroleum product storage shall be submitted to and approved by Plumas County Environmental Health prior to commencement of the operations.

7. If stationary fuel tanks are to be used in lieu of a mobile refueling truck, a Spill Prevention, Control and Counter Measures plan (SPCC) shall be submitted to Plumas County Environmental Health for review and approval prior to commencement of operations.

8. Sewage disposal, including any means of sewage disposal such as blue huts, shall be located at a minimum of 100 feet from the bank of any surface waters, water supply well, or natural spring. The Operator shall have a current and valid contract with an approved provider for routine service of such facilities.

9. All applicable permits for the operation, including but not limited to a National Pollutant Discharge Elimination System (NPDES) Storm Water Pollution Prevention (SWPPP) permit for the control, discharge, and monitoring of storm water, shall be adopted and issued by the California Regional Water Quality Control Board prior to commencement of the operations.

10. A copy of this permit (plan) shall be kept at the project site. The Operator shall oversee the permit's (plan's) implementation. Best Management Practices will be implemented during reclamation activities. If unforeseen circumstances require new and/or revised best management practices, they will be employed immediately by the Operator.

11. Reclamation may be performed on an annual basis, in stages compatible with continuing operations, or upon completion of all excavation, removal or fill. It is the responsibility of the Operator to reclaim the mined lands in accordance with the approved reclamation plan. The progress of mining and reclamation are subject to annual inspections to verify compliance with the plan, as required by Public Resources Code 2774 and California Code of Regulations 3504.5.

    In addition to the areas to be reclaimed each year, areas of disturbance not located within the active mining and processing area will require the implementation of temporary erosion control measures, as set forth in the permit/plan. These measures shall include, but not be limited to the following:

    a. Gravel piles which will exist throughout the winter will be surrounded by interceptor ditches (or berms) prior to the onset of the rainy season each year, and no later than October 15th of each year. Drainage will be directed to the mining pit or other appropriately-sized sediment traps. Erosion and sediment control best management practices will be installed pursuant to the SWPPP.

    b. Soil stockpiles which will exist throughout the winter, and which do not have sufficient existing vegetative growth to prevent erosion, will be seeded with grasses prior to the onset of the rainy season and no later than October 15 of each year. Erosion and sediment control best management practices will be installed around these stockpiles pursuant to the SWPPP.

    c. Areas that were stripped of vegetation to allow mining, but are not yet mined, will either drain to the mining pit or will be seeded with grasses prior to the onset of the rainy season and not later than October 15th of each year. Erosion and sediment control best management practices will be installed in these areas pursuant to the SWPPP.

    d. All other areas disturbed during mining shall either be seeded and/or have drainage established to the mining pit prior to the onset of the rainy season and not later than October 15th of each year. Exposed bedrock, boulder piles and rocks temporarily stockpiled are exempt from the seeding requirements.

12. A Streambed Alteration Agreement for the crossing of the North Fork Feather River and the temporary re-routing of Davis Creek shall be obtained from California Department of Fish and Wildlife prior to commencement of operations.

13. Appropriate permits for new on-site stationary equipment sources shall be obtained from the Northern Sierra Air Quality Management District.

14. The District Rules of the Northern Sierra Air Quality Management District are applicable to this project. Operator shall submit a Dust Control Plan to the Northern Sierra Air Quality Management District.

    a. Earthen materials excavated, processed, or stockpiled will be kept moist when conditions exist that be conducive to the generation of fugitive dust.

    b. Unpaved roads within the site used as haul roads will be watered to control dust when necessary. **MM 3A**

    Staff of the District shall monitor permit conditions. Planning staff, or qualified inspector, shall ensure that current permits and plans are in place on an annual basis at the time of the annual inspection.

15. Operator shall obtain appropriate entitlements for equipment operation and comply with permit conditions. **MM 3A**

16. A Streamside Management zone of a minimum 30-foot setback from the banks of the North Fork Feather River shall be maintained during the life of the operation. This setback may be increased by California Department of Fish and Wildlife, as necessary, to avoid riparian vegetation and to prevent discharge of mining waste or contact water to the river. Temporary orange construction fencing shall be installed around the outer edge of the streamside management zone in the area of active mining. The operator will ensure that all mining activities and equipment are restricted from the demarcated zone. Staff of the Planning Department or qualified representative will inspect and approve the location of the protective fencing before mining activities are initiated. **MM 4A**

17. If avoidance is not feasible, the Applicant will compensate for the loss of riparian vegetation by replanting riparian vegetation in suitable areas (as mapped by Wright, 2013) at the end of each season and after completion of each phase of the mining operation. Riparian vegetation will include planting species that are indigenous to the Site. Preferably, plants or cuttings will be obtained from onsite sources. Revegetation sites will be monitored for two to five years, or as specified in the streambed alteration agreement that will be obtained from California Department of Fish and Wildlife. **MM 4A**

18. Revegetation meeting all the requirements of California Code of Requirements section 3705 shall be performed on an annual basis after mining activities are completed. The recommendations of the *Revegetation, Mitigation and Monitoring Plan,* dated April 3, 2014 shall be followed to ensure that reclamation and revegetation is successful. **MM 4A**

19. Impacts to the wetland and riparian areas associated with Davis Creek shall be avoided by fencing and avoiding an area 20-feet on either side of the creek, and through proper installation of a culvert and rocked ford. Fencing shall be inspected prior to the commencement of operations and annually at the time of inspection by staff of the Planning Department or qualified representative. **MM 4A**

20. In order to prevent the spread of Himalayan blackberry, in areas to be mined the following season, foliage spray will be applied in the late summer or early fall, followed by burning or mowing 40 to 60 days after, as described in Section 2.19.3 of the *Surface Mining and Reclamation Plan for Seneca Mine, Mineral Patent CA 30606, Plumas County, CA,* prepared for Seneca Gold, LLC, by Holdrege & Kull. **MM 4B**

21. In an effort to avoid impacts to raptors and migratory birds, potential nesting habitat will be disturbed only after the nesting season (i.e., in the fall). In the area to be mined during the next season, woody vegetation that may serve as potential nesting habitat will be removed during the fall and may be used to re-plant the recently mined areas as part of reclamation. If nesting habitat is not removed during the fall, a qualified biologist must perform surveys of potential nesting habitat. **MM 4C**

22. Pre-construction surveys should be conducted by a qualified biologist three (3) days prior to ground disturbance or vegetation removal. If ground-disturbing activities are delayed or suspended for more than fifteen (15) days, the area should be re-surveyed. If the qualified biologist locates active nests of migratory birds or raptors, any such nests shall be flagged and avoided at a distance that prevents disturbance.

    Should project-related activities cause the nesting migratory bird or raptor to vocalize, make defensive flights at intruders, get up from a brooding position, or fly off the nest, then the exclusionary buffer should be increased such that activities are a sufficient distance from the nest to stop this agitated behavior by the bird or raptor. The exclusionary buffer should remain in place until chicks have fledged or as otherwise determined by a qualified biologist. **MM 4C**

23. Segments A, B, and C, as described in the *Archaeological Survey Report for the Testing Plan of Operations for the Grand Finale, Millie, and Ken Placer Claims, Plumas County, California, June 1995,* shall be flagged for avoidance prior to commencement of mining operations. Staff of Planning Department or qualified representative shall inspect the flagging prior to commencement of operations and annually at the time of inspection. **MM 5A**

24. A detailed financial assurance cost estimate and corresponding financial assurances shall be provided to the Planning Director for review and approval. Upon approval of the financial assurances by the Planning Director, and review by the Department of Conservation, Office of Mine Reclamation, a financial assurance mechanism shall be provided in a form acceptable to the Planning Director and the Department of Conservation, Office of Mine Reclamation. The financial assurance cost estimate shall be subject to annual review.

25. Financial assurances held for reclamation work will be released when the performance standards of the reclamation plan are satisfied.

26. The Permit to Mine/Reclamation Plan shall be signed and returned within forty (40) days of the date of approval or the permit will be voided.

Date ______________________

____
Randy Wilson
Planning Director/Zoning Administrator

I, the undersigned, understand and accept this Permit to Mine / Reclamation Plan and the conditions stated above and agree to comply with them. I further understand that failure to comply with any of the conditions may result in revocation procedures of the Permit being started by the Planning Director.

Estate of Lee Crowe (Owner)

Date ______________________

____
by David Preim

____
by Lorrie Preim

Date 8/11/14

____
Seneca Gold, LLC
Dean Deniz, Managing Member (Permittee)

This Permit to Mine / Reclamation Plan shall not be considered to be granted until it is signed by the permittee and owner, if applicable, and the Zoning Administrator, and a copy is filed in the Planning Department.

ATTACHMENT 13

Pacific Gas and Electric Company®

Power Generation

245 Market Street
San Francisco, CA 94105

Mailing Address
Mail Code N11C
P. O. Box 770000
San Francisco, CA 94177

April 30, 2012

Via Electronic Submittal (E-filing)

The Honorable Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
Hydropower Compliance and Administration
888 First Street, NE
Washington, DC 20426

Re: Rock Creek - Cresta Project (FERC No. 1962-191)
Submittal of the Water Temperature Under Article 401 and Appendix Condition 4D – Interim Control Measures

Dear Secretary Bose:

The Federal Energy Regulatory Commission (FERC) issued a new license to Pacific Gas and Electric Company (PG&E) for the Rock Creek-Cresta Hydroelectric Project, FERC No. 1962 (Project) on October 24, 2001 (97 FERC ¶ 61,084). Condition 4(d) of the license requires PG&E to prepare a report that evaluates whether mean daily temperatures of 20 degrees Celsius (°C) or less have been achieved in the Rock Creek and Cresta reaches, and, if not, whether additional reasonable control measures are available. The report was to include recommendations for the implementation of any such measures.

PG&E conducted an evaluation of measures to enhance coldwater habitat that could be funded under License Condition 4(e). The primary measures modeled and evaluated were modifications to achieve the withdrawal of colder water from the upstream reservoirs of the Upper North Fork Feather River Project (FERC No. 2105). An informational progress report on water temperature monitoring, modeling and control options was filed by PG&E on September 21, 2005. The Project No. 2105 license expired on October 31, 2004, and is currently operating under an annual license. The current evaluation efforts are focused on the environmental review process in support of a 401 certification by the California State Water Resources Control Board (Board).

PG&E's July 24, 2007 letter noted that this study effort was expected to produce valuable information for reasonable control measures evaluation. PG&E's July 31, 2008 letter noted the Board had completed a level 1 and level 2 analysis and had progressed to a level 3 analysis, which is taking a more focused look at the most promising water temperature control options. At its January 14, 2009 meeting, the Rock Creek – Cresta Ecological Resources Committee (ERC) and United States Forest Service (FS) discussed the status of the study efforts under the Project 2105 environmental review process. The Board representative stated that the level 3 analysis was nearing completion. In addition, the Board representative stated that the analysis would be included as an appendix to the draft Environmental Impact Report (EIR).

The ERC and FS has recognized that the draft EIR and accompanying level 3 analyses will greatly assist in the discussion of primary temperature control measures, as well as any additional reasonable control measures. During the April 2011 ERC meeting, PG&E informed the ERC that we would prepare a letter to FERC requesting an extension to the Condition 4(d) report, in the anticipated release schedule of the draft EIR. The ERC supported the proposed time extension to August 31, 2012.

FERC granted an extension to May 1, 2012, but indicated that any additional request for extension of time to file the Additional Reasonable Control Measures Report shall be accompanied by a proposal, developed in consultation with the ERC, to implement interim water temperature control measures. FERC also required that this filing include copies of the comments and recommendations of the ERC regarding the interim control measures and the licensee's description of how the proposed interim control measures accommodate the comments of the ERC and FS. The licensee was also required to allow a minimum of 30 days for the ERC and FS to comment and to make recommendations before filing any request for an additional extension of time and proposed interim temperature control measures with the FERC. Attached is the "*Interim Temperature Control Measures Plan*." These interim control measures were discussed at the January, February, March, and April 2012 ERC meetings. The draft Plan was e-mailed to the members of ERC and FS, and PG&E received concurrence on the Plan from all currently active ERC members, including: the United States Forest Service, California Department of Fish and Game, California State Water Resources Control Board, California Sportfishing Protection Alliance, Plumas County, and American Whitewater (attached). PG&E received one comment pertaining to the on-going discussions during the ERC meetings to support fish and amphibian passage into the tributaries, and this was included as Interim Measure 5 in the attachment. No other comments were received.

As of the date of this letter, the draft EIR for Project 2105 has still not been distributed by the Board. The ERC and FS, consequently, requests an extension of time to receive and review the EIR in order to conduct the appropriate evaluation of additional measures to enhance coldwater habitat that could be funded under License Condition 4(e), and to develop the Condition 4(d) report. Therefore, PG&E is requesting another extension of time until May 1, 2013.

If you have any questions, please call me at (415) 973-3642.

Sincerely,

Charles White, Senior License Coordinator
Hydro Licensing

Attachments

cc: Attached List

cc: Terri Simon-Jackson
Plumas National Forest
P.O. Box 11500
Quincy, CA 95971

Amy Lind
U.S. Forest Service
Sierra Nevada Research Center
1731 Research Park Dr.
Davis, CA 95618

Sharon Thrall
Plumas County Supervisor
P.O. Box 368
Chester, CA 96202

Mary Lisa Lynch
California Department of Fish and Game
1701 Nimbus Road, Suite A
Rancho Cordova, CA 95670

Peter Barnes
State Water Resources Control Board
P. O. Box 2000
Sacramento, CA 95812

Chris Shutes
CA Sportfishing Protection Alliance
1608 Francisco Street
Berkeley, CA 94703

Nate Rangel
CA Outdoors
PO Box 401
Coloma, CA 95613-0401

Bob Center
Friends of the River
1418 20th Street, Ste 100
Sacramento, CA 95811

Curtis Knight
California Trout
P. O. Box 650
Mt. Shasta, CA 96067

Dennis Smith
U. S. Forest Service
650 Capitol Mall, Suite 8-200
Sacramento, CA 95814-4706

Deborah Giglio
U. S. Fish and Wildlife Service
2800 Cottage Way, Room W-2605
Sacramento, CA 95825

Leah Wills
Plumas County
520 Main Street, Rm. 302
Quincy, CA 95971

Laurie A. Soule
California Department of Fish and Game
North Central Region
1701 Nimbus Road, Ste. A
Rancho Cordova, CA 95670

Dave Steindorf
American Whitewater
4 Baroni Drive
Chico, CA 95928

Stephen Bowes
National Park Service
1111 Jackson Street
Oakland, CA 94607

John Beuttler
CA Sportfishing Protection Alliance
1360 Neilson Street
Berkeley, CA 94702

Richard Roos-Collins
Water and Power Law Group
2140 Shattuck Avenue, Ste. 801
Berkeley CA 94704

Attachment A

Interim Temperature Control Measures

Rock Creek-Cresta Project
FERC No. 1962

Interim Temperature Control Measures

Background

The Federal Energy Regulatory Commission (FERC) issued to Pacific Gas and Electric Company (PG&E) a new license for the Rock Creek-Cresta Project, FERC No. 1962 (Project) on October 24, 2001. The License required the submission of the Additional Reasonable Control Measures report under Condition 4D (4D Report) within five years of the date when FERC approved the water temperature monitoring plan. FERC approved the water temperature plan in June 2002.

PG&E conducted an evaluation of measures to enhance coldwater habitat that could be funded under License Condition 4E. The primary measures modeled and evaluated were modifications to achieve the withdrawal of colder water from the upstream reservoirs on the Upper North Fork Feather River Project (UNFFR), FERC No. 2105. An informational progress report on water temperature monitoring, modeling and temperature control options was filed by PG&E on September 21, 2005. The UNFFR Project license expired on October 31, 2004 and is currently operating under an annual license. Following the guidelines and protocol of California Environmental Quality Act (CEQA), the current evaluation efforts are focused on the environmental review process in support of a 401 certification by the California State Water Resources Control Board (SWRCB).

PG&E's July 24, 2007 letter noted that the CEQA study effort was expected to produce supporting information for the evaluation. PG&E's July 31, 2008 letter noted the SWRCB had completed a level 1 and level 2 analysis and had progressed to a level 3 analysis, which is taking a more focused look at the most promising water temperature control options, which are in UNFFR project. The level 3 analysis was released on December 20, 2011.

The United States Forest Service (USFS) and the Rock Creek-Cresta Ecological Resources Committee (ERC) has recognized that the draft Environmental Impact Report (EIR) will greatly assist in the discussion of primary temperature control measures, as well as help with the analysis of any additional potential reasonable control measures. During the April 2011 ERC meeting, PG&E informed the ERC that they would prepare a letter to FERC requesting an extension to the Condition 4(d) report, in the anticipated release schedule of the draft EIR. With its May 11, 2011 letter, PG&E requested an extension of time to file the Addition Reasonable Control Measures Report to August 31, 2012, which was supported by the ERC.

FERC granted an extension to May 1, 2012, but indicated that any additional request for extension of time to file the Additional Reasonable Control Measures Report shall be accompanied by a proposal, developed in consultation with the ERC, to implement interim water temperature control measures. FERC also required that this filing include copies of the comments and recommendations of the ERC regarding the interim control measures and PG&E's description of how the proposed interim control measures accommodate the comments of the ERC. PG&E was also required to provide the ERC a minimum of 30 days to comment and to make recommendations before filing any request for an additional extension of time and/or proposed interim temperature control measures with the FERC. The following is PG&E's plan to address the interim temperature control measures to reduce water temperatures in the Rock Creek and Cresta reaches prior to the release of the draft UNFFR EIR.

Interim Control Measures

PG&E operates the Rock Creek and Cresta facilities in accordance with minimum instream flow requirements in License Condition 5. Additionally, as required by License Condition 4, PG&E monitors water temperatures in both the Rock Creek (PG&E Gage No. NF-57) and Cresta (PG&E Gage No. NF-56) reaches. If the daily average water temperature exceeds 20°C for two consecutive days, measured midnight to midnight for each 24 hour period, PG&E notifies the USFS and ERC of the temperature exceedence and informs the USFS and ERC of the actions being taken to decrease the water temperatures in an effort to maintain a daily average water temperature of 20°C or less.

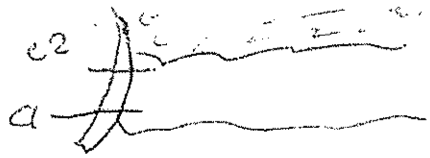
Interim Measure 1

If the daily average water temperature in the Rock Creek or Cresta reach exceeds the 20°C criterion for two consecutive days, PG&E will maximize the release of the minimum instream flow requirement at each reservoir to the low-level outlet located approximately 30-feet below the invert of the radial gates. The change in the water release from the surface radial gate to the low-level outlet could potentially provide deeper, cooler water to the Cresta and Rock Creek reaches. Results?

Interim Measure 2

PG&E will implement a program that will preferentially operate the Caribou 1 Powerhouse over the more efficient Caribou 2 Powerhouse once the temperature criterion is exceeded. Caribou 2 primarily withdraws surface water whereas Caribou 1 (deep) Powerhouse has the potential to access a limited amount of colder water from the deeper portions of Butt Valley Reservoir and deliver to the Rock Creek and Cresta reaches. In order to preserve the finite amount of colder water in Butt Valley Reservoir, PG&E will attempt to maintain Butt Valley Reservoir at maximum pool and minimize the operation of Caribou 1 until July 15 or the first occurrence of average daily temperatures in either the Rock Creek Reach (NF-57) or Cresta reach (NF-56) exceeding 20°C for two days, whichever occurs sooner. During this special Caribou 1 operation[1], Caribou 2 will reduce its operation as much as is reasonably possible to

[1] The above action is not intended to restrict the operation of either Caribou 1 or Caribou 2 in meeting system power needs during system alerts, warnings or stage emergencies. Also, Caribou 1 is routinely used for meeting peak loads for several hours on days with high energy demand, which may reduce, over time, the amount of cold water available in Butt Valley Reservoir.



minimize the mixing with surface water. This operation will be for a period of 5 days as effective colder water withdrawal from Caribou 1 diminishes after this period.

Interim Measure 3

In the report "*North Fork Feather River Study Data and Informational Report on Water Temperature Monitoring and Additional Reasonable Water Temperature Control Measures*" filed with FERC on September 19, 2005, PG&E determined that the current configuration and operation of the Bucks Project provided very favorable water temperature benefits to the NFFR. PG&E will continue to operate the Bucks Creek Powerhouse in a manner that will help reduce daily average water temperatures both in the lower Rock Creek Reach (between Bucks Creek and Rock Creek powerhouses) and the Cresta Reach. Bucks Creek Powerhouse discharges to the NFFR approximately 1 mile upstream of Rock Creek Powerhouse and has significantly cooler water, which will benefit the lower Rock Creek Reach (about 12% of the total Rock Creek reach) and the Cresta reach.

Interim Measure 4

During critically dry years, after implementing Interim Measures 1 through 3 and when daily average temperature at NF-57 or NF-56 are above 20ºC, the minimum instream flow from the Rock Creek (150 cfs) and Cresta (140 cfs) dams will be increased to 200 cfs, or to any flow in between 150/140 cfs to 200 cfs, to the extent necessary to contribute to the maintenance of mean daily temperatures of 20ºC or less in the respective reach. The increase will be in daily increments of approximately 20 cfs until which time the daily average temperature is less than or equal to 20ºC or the flow release is 200 cfs

Similarly, this increased flow shall be reduced back to the minimum instream flow, when not required to maintain mean daily temperatures of 20ºC. Any flow adjustments will be made in the early morning to allow enough time to reflect any temperature change at NF-57 and NF-56 that peaks in the late afternoon.

Interim Measure 5 Doins

PG&E, the USFS, and the ERC will finalize a Letter of Intent (LOI) to participate in ongoing efforts to address fish and amphibian passage issues in tributaries to the North Fork Feather River. This LOI could provide access to cold-water refugia and potentially increase the overall aquatic productivity in the NFFR. PG&E, the USFS, and the ERC recognize that access for aquatic biota to NFFR tributaries is an issue of great importance not only within the Project waters, but for the health of the entire watershed.

Reporting

PG&E will determine the effectiveness of the interim control measures and the results will be reported in the Rock Creek – Cresta Annual Report filed with FERC each year.

Attachment B

Agency Correspondence

White, Charles

From: Smith, Dennis E -FS <dennissmith@fs.fed.us>
Sent: Friday, April 27, 2012 2:43 PM
To: White, Charles
Cc: SimonJackson, Terri -FS; Lind, Amy -FS
Subject: RE: Letter to FERC, Interim Control Measures, and LOI

Charlie,

The USDA Forest Service has reviewed the DRAFT Rock Creek–Cresta Project (FERC NO. 1962) Interim Temperature Control Measures Draft document. We agree that the review of the Upper North Fork Feather River Project (FERC No. 2105) EIR is necessary in order to conduct the appropriate evaluation of additional measures to enhance coldwater habitat that could be funded under License Condition 4(e), and to develop the Condition 4(d) report. For that reason the USDA Forest Service agrees with PG&E's request for an additional extension of time until May 1, 2013 to file these Condition 4(e) measures and the 4(d) report with FERC.

With this agreement for an extension of time the USDA Forest Service requests to be notified within 24 hours of excursions in temperature that necessitate implementation of any of the five interim measures and what specific interim measure is being taken. We also would like notification within 48 hours after an interim measure is taken as to its effectiveness and if the measure taken is not effective, what addition interim control measures will be taken to return stream temperatures to below 20ºC.

If you have any questions about the specifics of our support for an extension of time, don't hesitate to contact me.

R/
Dennis

Dennis Smith
USDA Forest Service
Pacific Southwest Region
Regional Hydropower Assistance Team Project Manager
1323 Club Drive
Vallejo, CA 94592
dennissmith@fs.fed.us
707-562-9176 Office
916-849-8039 Cell
707-562- 9055 Fax

From: White, Charles [mailto:COW1@pge.com]
Sent: Friday, April 27, 2012 1:38 PM
To: Smith, Dennis E -FS
Subject: Letter to FERC, Interim Control Measures, and LOI

Dennis,

Here is the submittal package that I am planning to send to FERC. All the other active members of the ERC have indicated their concurrence with the proposed Interim Control Measures.

Thank you for looking at this.

Charles White
Pacific Gas and Electric Company
245 Market Street, 1120B, San Francisco, CA 94105
Mailing: MC N11C, PO Box 770000, San Francisco, CA 94177
(415) 973-3642 Office
(925) 487-5270 Cell
cow1@pge.com

White, Charles

From: leah wills <leah2u@frontiernet.net>
Sent: Wednesday, April 25, 2012 5:02 PM
To: White, Charles
Cc: Sherrie Thrall; Randy Wilson; Albietz, Jessica
Subject: Re: Draft Interim Temperature Control Measures

Hi Charlie,

Good luck with your new job. It has been great to work with you.

Plumas County supports the Interim Control measures as proposed with the following suggested edits. Plumas would like to retain the cold water pool in But Valley reservoir as long as possible to lessen the cumulative heat strain on the trophy cold water trout fishery in the reservoir. So please defer the preferential use of Caribou 1 as long as possible in the heat storm season this year. Also, could you identify how the ERC will be notified of the interim water measures/actions that you do you take this year? And finally, the ERC has identified that moving ahead with the signing of the LOI is part of this summer/fall interim coldwater trout habitat measures.

The habitat/temperature/flows nexus is something the ERC will be working on for the rest of this year, although you may miss it.
Oh, too bad for you.

The approval of the LOI is scheduled on the May 15th, 2012 Plumas County Board of Supervisor's agenda.

Plumas County would like to see the signing of the LOI added to the Interim Measures document if you think the LOI is not too far "off topic" with FERC.

Best, Leah
On Apr 2, 2012, at 2:28 PM, White, Charles wrote:

ERC Members,

Attached is the draft Interim Temperature Control Measures recommendations. These are recommendations that we discussed at the February and March ERC meetings. I would like to get your comments April 26th.

This is also posted on the RCC ERC website.

Charles White
Pacific Gas and Electric Company
245 Market Street, 1120B, San Francisco, CA 94105
Mailing: MC N11C, PO Box 770000, San Francisco, CA 94177
(415) 973-3642 Office
(925) 487-5270 Cell
cow1@pge.com

<Interim Temperature Control Measures (ERC Review)_JA1.docx>

White, Charles

From: Chris Shutes <blancapaloma@msn.com>
Sent: Wednesday, April 18, 2012 11:58 AM
To: White, Charles; Albietz, Jessica
Cc: Peter Barnes; Laurie Soule; Herman, Andie; Amy Lind; Running, Stuart; Dave Steindorf; Leah Wills
Subject: Interim temperature report

Charlie,

I approve the draft "Interim Temperature Control Measures" for the Rock Creek - Cresta Project, as outlined in the April 5, 2012 review draft.

More permanent potential measures to improve summer water temperatures in the North Fork Feather River between Lake Almanor and Lake Oroville will become more evident with the issuance by the State Water Resources Control Board of its EIR for the 401 Water Quality Certification for the Upper North Fork Feather Project. CSPA looks forward to working with other stakeholders in reviewing the EIR, and developing permanent measures to improve summer water temperatures in the North Fork Feather River, pursuant to the 401 process for the Upper North Fork Feather Project.

Chris Shutes
FERC Projects Director
California Sportfishing Protection Alliance

White, Charles

From: Laurie Soule <LSOULE@dfg.ca.gov>
Sent: Wednesday, April 25, 2012 2:11 PM
To: White, Charles
Subject: Re: Draft Interim Temperature Control Measures

DFG concurs with the draft Interim Temperature Control recommendations. Thank you.

Laurie A. Soule
Staff Environmental Scientist
California Department of Fish and Game
North Central Region
1701 Nimbus Road, Ste. A
Rancho Cordova, CA 95670
916-358-2847

>>> On 4/2/2012 at 2:28 PM, "White, Charles" <COW1@pge.com> wrote:

ERC Members,

Attached is the draft Interim Temperature Control Measures recommendations. These are recommendations that we discussed at the February and March ERC meetings. I would like to get your comments April 26th.

This is also posted on the RCC ERC website.

Charles White
Pacific Gas and Electric Company
245 Market Street, 1120B, San Francisco, CA 94105
Mailing: MC N11C, PO Box 770000, San Francisco, CA 94177
(415) 973-3642 Office
(925) 487-5270 Cell
cow1@pge.com

White, Charles

From: Peter Barnes <PBarnes@waterboards.ca.gov>
Sent: Wednesday, April 25, 2012 11:52 AM
To: White, Charles
Subject: Re: Draft Interim Temperature Control Measures

Charlie,

The proposed measures look good. I understand that the UNFFR Draft EIR will help inform future decisions and am working diligently towards its completion.

Sincerely,

Peter Barnes
Engineering Geologist
Division of Water Rights
State Water Resources Control Board
Phone: (916) 445-9989
Email: pbarnes@waterboards.ca.gov
>>> "White, Charles" <COW1@pge.com> 4/2/2012 2:28 PM >>>
ERC Members,

Attached is the draft Interim Temperature Control Measures recommendations. These are recommendations that we discussed at the February and March ERC meetings. I would like to get your comments April 26th.

This is also posted on the RCC ERC website.

Charles White
Pacific Gas and Electric Company
245 Market Street, 1120B, San Francisco, CA 94105
Mailing: MC N11C, PO Box 770000, San Francisco, CA 94177
(415) 973-3642 Office
(925) 487-5270 Cell
cow1@pge.com

White, Charles

From:	Dave Steindorf <dave@americanwhitewater.org>
Sent:	Thursday, April 26, 2012 4:33 PM
To:	White, Charles
Subject:	Re: Draft Interim Temperature Control Measures

Charlie,
This report has my approval to go to FERC.
Dave

Dave Steindorf
California Stewardship Director
American Whitewater
4 Baroni Drive
Chico, CA 95928
Office 530.343.1871
Cell 530.518.2729

Join or donate today!
www.americanwhitewater.org

On Apr 2, 2012, at 2:28 PM, White, Charles wrote:

ERC Members,

Attached is the draft Interim Temperature Control Measures recommendations. These are recommendations that we discussed at the February and March ERC meetings. I would like to get your comments April 26th.

This is also posted on the RCC ERC website.

Charles White
Pacific Gas and Electric Company
245 Market Street, 1120B, San Francisco, CA 94105
Mailing: MC N11C, PO Box 770000, San Francisco, CA 94177
(415) 973-3642 Office
(925) 487-5270 Cell
cow1@pge.com

<Interim Temperature Control Measures (ERC Review)_JA1.docx>

ATTACHMENT 14

DRAFT

Biological Issues Associated with the Contemplated Lake Almanor Water Temperature Curtain at the Prattville Intake

Dave Vogel, Senior Scientist
Natural Resource Scientists, Inc.
P.O. Box 1210
Red Bluff, CA 96080

Summary

A limited assessment of some of the more prominent biological issues associated with a potential water temperature curtain at Lake Almanor's Prattville intake was conducted; it is not comprehensive and was restricted to readily available documents. However, based on this assessment, it is evident that major uncertainties exist as to potential fishery resource benefits that may result from the curtain. The ecological impacts are unknown, but the risk to the resource appears to be high. The installation of water temperature curtains in Lake Almanor and Butt Valley Reservoir may be particularly risky propositions because of the tenuous nature of the reservoir ecosystems and predicted adverse impact to the fishery resources.

Based on documents reviewed, I concluded that the potential benefits that may result in the Rock Creek – Cresta reach of the NFFR are vague and speculative. Most importantly, none of the documents provided a clear description of the fishery resource tradeoffs between presumed increased trout growth (during late summer) for an unknown number of fish in the NFFR bypassed reaches versus the adverse impacts to the substantial trout fishery in upstream reservoirs. This circumstance is mostly attributable to a lack of detail on modeling assumptions/limitations and the absence of a comprehensive integration of modeling scenarios for various alternatives under consideration for temperature control. Clearly, the magnitude of those tradeoffs must be articulated before a decision can be made as to the overall benefits or detriments of the temperature curtain.

It's apparent that advocating for installation of the temperature curtain is premature until additional research and studies are conducted. However, given the uncertainties with the Prattville curtain, the anticipated biological impacts, and intangible benefits, it is unclear why the curtain option is still under consideration. A clearly-defined, integrated description of specifically how the temperature curtain may affect the fishery resource from Lake Almanor to the downstream NFFR reaches and limitations on modeling uncertainties is essential.

Introduction

The following is a limited assessment of biological issues associated with a proposed temperature curtain in front of PG&E's Prattville Intake in Lake Almanor. The objective of this action is solely focused on reducing water temperatures in the North Fork Feather

> *bypassed reaches (PG&E, 2002a,c). We do not consider these model results to be adequate to evaluate conditions proposed in the final SA* [Settlement Agreement], *since proposed MIFs* [minimum instream flows] *would vary considerably for the model period (March 1 to September 30). Therefore, we conclude that modeling additional scenarios, including incorporation of the proposed and recommended flow regimes would provide the information needed to assess the effects that implementing the potential control measures identified in the Rock Creek – Cresta SA and the Interior and FS filings with the Commission dated December 1, 2003, would have on the thermal regime of Lake Almanor, Butt Valley Reservoir, and the NFFR.*" (FERC 2004)

And, although FERC concluded that there may be opportunities to reduce NFFR water temperatures, the draft EIS states:

> "*However, available information is not sufficient to determine the effects that modifying the Prattville intake in conjunction with PG&E proposed and agency recommended water level and flow regime restrictions for the project would have on the thermal regime of Lake Almanor, Butt Valley Reservoir, and the NFFR. Furthermore, altered operations (particularly with a modified Prattville intake) would change the hydrodynamics of Lake Almanor and consequently alter DO profiles in the reservoir.*"
>
> "*The combination of alteration of the thermal and DO conditions in Lake Almanor could substantially shift the ability of the reservoir to support its existing coldwater and warmwater fisheries. Using the coldwater in Lake Almanor and/or shifting operations of the Caribou developments could also affect the thermal regime and DO levels in Butt Valley reservoir and could adversely affect the existing trophy rainbow and brown trout fishery of the reservoir. We agree with FS and Interior that additional temperature and DO modeling is needed prior to implementing any structural modifications. PG&E is currently conducting this modeling effort as part of the Rock Creek – Cresta Project settlement.*"

The summer stratification characteristics in Lake Almanor vary significantly between years (Gast 2004) indicating that modeling those variations would be difficult without sufficient validation of model outputs with empirical data. Comparing empirical data for water temperature profiles collected by the California Department of Water Resources, Gast (2004) clearly demonstrated the large variations in temperature profiles between years. It is not evident that the Prattville model validation accounted for those large variations between years. In fact, it appears that an average of June, July, and August 2000 water temperature profiles (three separate average profiles) were used in the hydraulic modeling effort (Ettema et al. 2004). These average profiles would not reflect the large variability in summertime profiles evident in Lake Almanor. For example, Gast (2004) provides data comparing July profiles in 1995 and 2002 where a 5-6°C variation between years was evident at varying depths in the epilimnion and a 3-4°C variation at varying depths in the hypolimnion. It is not clear how or if the modeling efforts accounted for such large variations. Such large variations would undoubtedly affect modeling outputs.

It is also not clear if and/or how the Lake Almanor hydraulic modeling effort accounted for between-month sequential changes in conditions with the modeled Prattville curtain in place. Although it is not entirely clear to me, the report by Ettema et al. (2004) suggests that the modeling efforts treated June, July, and August as independent modeling runs. It appears that each month's model runs were initially established with baseline conditions reflecting water profiles without the curtain. If not, it should be clarified. If so, those conditions would not reflect how the Prattville curtain would affect water temperature profiles in Lake Almanor over the course of the summer, not just in isolated months, treated independently. Operation of the Prattville curtain will alter Lake Almanor's hydrodynamics (FERC 2004). For example, during August conditions, with the temperature curtain in place, the water temperature profile would have been established based on how the sequential June and July conditions led up to the August conditions. With the curtain in place, potential depletion of the cold water hypolimnion could be significantly reduced by August and a significant decline in thermocline depth could occur during the summer.

The SNTEMP model for the NFFR was not reviewed for this assessment. However, if the anticipated reduction in water temperatures in the Rock Creek – Cresta reach is anticipated to be relatively small, it will be important to examine the temperature validation data for the NFFR modeling effort. For example, Bartholow (2000) states: "*SNTEMP predicts well, generally less than 0.5 C on average and less than 1.5 C most of the time, given representative input data.*"

Because the ultimate goal of the temperature control curtain is to reduce water temperatures in downstream NFFR reaches, the modeling outputs must be viewed in the context of variable validities of each model. For example, each of the reservoir and stream reach models possesses some variation in accuracy compared to actual conditions. Each model's departure from actual conditions compound the problem as the independent model outputs are built onto one another. Caution should be exercised to ensure that the final model outputs for the downstream-most reaches of the NFFR are not interpreted to portray accurate results when the models themselves may not capable or sensitive enough to provide that level of accuracy.

Potential Benefits to Trout in Downstream Reaches of the NFFR

The mainstem dams on the NFFR block upstream movements of all fish and do not possess fish passage facilities (FERC 1996, FERC 2004). Under natural conditions without dams and during summer periods when riverine water temperatures increased, fish could have migrated to upstream reaches seeking cooler water. FERC (1996) reported[4] that before construction of the Rock Creek – Cresta Project in 1950, an excellent trout fishery existed in the NFFR reach now bounded by the Rock Creek

[4] Citing USFS 1938, Wales and Hanson 1952, and USFWS 1948.

development. The NFFR reach now bounded by the Cresta development was limited to only early season use because of warm, midsummer temperatures. Most notably, FERC (1996) stated that:

> "*The creation of the reservoirs* [Rock Creek and Cresta], *along with flow reduction in the bypass reaches and increased water temperatures, changed the NFFR's aquatic habitat to favor nongame species rather than trout.*"[5]

Moyle et al. (1983) describe hydrologic characteristics of the NFFR reach with the four impoundments (Poe, Cresta, Rock Creek, and Belden) as follows:

> "*The annual flow regime has been highly modified, so that former extreme spring floods and summer low flows have been largely eliminated.*"

This indicates that the existing summertime flows are now higher than they were historically, through releases of stored water. With summertime flows higher, water temperatures could now be lower than historical conditions in these reaches, but is speculative without data to support that premise. Because construction of the Rock Creek – Cresta Projects blocked the migratory corridor, trout cannot migrate to thermal refugia in upstream reaches. Apparently, the provision of fish passage at these dams has not been considered a viable option. If fish passage was provided, it could partially obviate the need for temperature control at Almanor. It would appear that the thermal curtain at Prattville would, in part, mitigate for effects of increased NFFR temperatures and fish blockage caused by the Rock Creek – Cresta Project. It is particularly relevant that in 1996 FERC concluded that the provision of fish passage at Rock Creek and Cresta Dams "*... is not necessary to complete the life cycle of native species in the NFFR and, therefore, we do not recommend that the need for fish passage be investigated.*" (FERC 1996).

The existing use of water temperature curtains in the northern California Reservoirs of Lewiston and Whiskeytown and the temperature control device at Shasta Reservoir are for the specific purpose of protecting winter-run Chinook salmon eggs during incubation. Salmon eggs have a very narrow thermal tolerance. At the upper limit of salmon eggs thermal tolerance, just a degree or two Celsius increase can cause major mortality (e.g., 100% mortality at 16.7°C). Juvenile and adult rainbow trout do not have such a very narrow thermal tolerance as compared to salmon eggs. The biological intent of the Prattville temperature curtain is to provide optimal, not non-lethal, thermal conditions for trout rearing in specific reaches of the NFFR. Temperatures slightly exceeding 20°C would not cause fish mortality, although the conditions would be sub-optimal. In fact, rainbow trout can tolerate water temperatures as high as 25.5°C for short periods with no mortality[6] (Leitritz and Lewis 1976). Piper et al. (1982) lists 25.5°C as the upper range in temperature requirement for rainbow trout; water temperatures exceeding approximately

---

[5] Citing USFWS 1962, Moyle et al. 1983, and PG&E 1979.

[6] "It is quite generally agreed that yearling and adult rainbow trout can withstand temperatures up to 78°F for short periods of time without harmful effect." (Leitritz and Lewis 1976).

25.5°C are potentially lethal (Hunter 1991). Lee and Rinne (1980) reported a critical thermal maxima[7] of 29.35°C for rainbow trout acclimated to 20°C. Scott and Crossman (1973) state:

> *"Rainbow trout are most successful in habitats with temperatures of 70°F (21°C) or slightly lower, but so long as there is cooler, well-oxygenated water into which they can retreat they can thrive in lakes which warm at the surface to well over 70°F (21°C) for long periods in the summer."*

This upper criterion is consistent with Raleigh et al. (1984) (as cited by Gast 2004) reporting an upper preferred temperature of 21°C for adult rainbow trout.

Although the reasons why are not fully known or understood, it is apparently empirically evident that trout survive in the Rock Creek - Cresta Reach under existing thermal conditions, but are outnumbered by other warmer-water species (FERC 1996, FERC 2004). In fact, FERC (1996) indicated that the creel surveys from 1981 to 1985 in each of the Rock Creek and Cresta bypassed stream reaches showed that wild rainbow trout made up 45% of the anglers' catch. The draft FERC EIS describes the trout fisheries in the NFFR bypassed reaches as in "*good condition*" (FERC 2004). Trout may find thermal refugia in tributaries or the mainstem (e.g., deep pools or near tributary confluences) at the hottest days in summer or water temperatures may not be a limiting factor for trout in this reach. With the exception of 1977, Moyle et al. (1983) found that, "*During most summers, rainbow trout probably found temperatures optimal for growth in the lower reach...*" downstream of Rock Creek dam. During the severe drought of 1977, Moyle et al. (1983), citing PG&E records, found that with very low flows in the Rock Creek bypassed reach, summer water temperatures (maximum daily) were sub-optimal (exceeding 20°C) and approached, but did not exceed, lethal limits for rainbow trout.

However, trout spawning habitat/gravels in this reach is considered a significant factor limiting trout populations. FERC (1996), citing CDFG (1988), states that the trout fishery is limited, in part, due to lost spawning habitat:

> *"Rock Creek and Cresta Dams prevent adult trout access to upstream spawning areas in the mainstem and tributaries, and they reduce gravel recruitment from upstream sources. From Rock Creek dam to Poe dam, access to spawning habitat is further restricted by highway and railroad culverts that block passage to 8 of 14 tributaries, within 300 meters of their mouths."*

Additionally, Moyle et al. (1983) suggested that the smaller trout population in the lower reaches of the NFFR (as compared to upper reaches) may be attributable to physical channel habitats available for trout (e.g., poor pool habitat). The authors recommended "*In the lower reach, the continuous stocking of hatchery fish is apparently the only way substantial trout populations can be maintained.*"

[7] "that temperature at which the fish loses its ability to escape lethal conditions" (Lee and Rinne 1980)

The goal of reduced temperatures in trout habitat when existing conditions are near or exceed the upper thermal optimum is desirable, if net adverse impacts don't result from measures to achieve that goal. It appears that the primary purpose for the intended provision of 20°C or less in downstream reaches of the NFFR is to simply achieve some level of improved growth for trout during late summer. For example, the draft FERC EIS provides the following supporting rationale for a combination of increased flows and decreased temperatures in the NFFR bypassed reaches:

> "*The condition of rainbow trout would be expected to improve and could result in anglers catching larger trout from the Seneca and Belden bypassed reaches downstream from the Belden and Rock Creek dams, respectively.*" (FERC 2004)

However, based on documents reviewed, I concluded that the potential benefits that may result in the Rock Creek – Cresta reach of the NFFR are vague and speculative. This circumstance is mostly attributable to a lack of detail on modeling assumptions/limitations and the absence of a comprehensive integration of modeling scenarios for various alternatives under consideration for temperature control.[8] The reservoir and river models should be assessed to determine if they are sufficiently accurate, when used in combination, to predict such a small incremental decrease in water temperatures at that location. Additionally, that effort should also include a meaningful description of specifically what resource benefits may result from incremental changes in the existing temperature regime.

Most importantly, none of the documents reviewed provided a clear description of the fishery resource tradeoffs between presumed increased trout growth (during late summer) for an unknown number of fish in the NFFR bypassed reaches versus the adverse impacts to the substantial trout fishery in upstream reservoirs. As stated in the draft FERC EIS (2004): "*At this time, however, the ERC* [Ecological Resources Committee] *has not completed the studies being conducted to determine the feasibility of modifying the Prattville intake to provide cooler water to downstream reaches, and the costs, benefits, and effects (both beneficial and adverse) of modifying the Prattville intake are unknown.*" Clearly, the magnitude of those tradeoffs must be articulated before a decision can be made as to the overall benefits or detriments of the temperature curtain.

As a final note, it is important to recognize that experience with temperature curtains elsewhere in northern California demonstrated that the devices functioned differently than predicted and required expensive modifications to improve performance (Gast 2004, cited pers. comm. with G. O'Haver, USBR). Given that circumstance, it would strongly suggest that temperature curtains at the Prattville intake and in Butt Valley Reservoir may be particularly risky propositions because of the tenuous nature of the two reservoir ecosystems and predicted adverse impacts to the fishery resources.

[8] These documents may exist, but were not available for this limited assessment.

In 1996, FERC reported, "*Recently, PG&E and CDFG agreed to delete the Prattville intake improvement and associated temperature monitoring and, in its place, implement as yet unspecified fishery enhancement measures.*" FERC (1996) also concluded, "*We therefore agree that fishery enhancement measures would provide greater benefits for fishery resources than could be obtained by installing temperature control structures at the Prattville and Caribou No. 2 intakes.*" Given the uncertainties with the Prattville curtain, the anticipated biological impacts, and intangible benefits, it is unclear why the curtain option is still under consideration.

Conclusion

It is apparent that considerable uncertainties remain concerning the potential resource benefits or detriments associated with the Prattville temperature curtain. No documents were reviewed that provided any certainty that purported temperature benefits to trout will be realized in the downstream reaches of the NFFR. In fact, it is evident that the temperature curtain may result in overall negative biological impacts to upstream trout fisheries. Notably, although the impacts would be believed to occur with reasonable certainty, evidence for the purported benefits in the NFFR is not compelling, largely because the potential biological benefits are vague and ill-defined. Much, if not most, of the biological issues appear to be a tradeoff of resource benefits that may result from the curtain. The result is a tradeoff of uncertain, undefined benefits of a slight decline in water temperatures during a portion of the summer for reasonably certain adverse impacts to upstream reservoirs. A clearly-defined, integrated description of specifically how the temperature curtain may affect the fishery resource from Lake Almanor to the downstream NFFR reaches and limitations on modeling uncertainties is essential.

References

Bartholow, J.M. 2000. SNTEMP (In)frequently asked questions. Fort Collins, CO: U.S. Geological Survey. 34 p.

DeCota, R. 2003. Letter from Ron DeCota, fishery biologist, to Magalie R. Salas, Federal Energy Regulatory Commission re. comments on the scoping document for the Upper North Fork of the Feather River Hydroelectric Project, FERC No. 2105-089. 4 p.

Ettema, R., M. Muste, J. Odgaard, and J. Lai. 2004. Lake Almanor cold-water feasibility study: hydraulic model. IIHR Technical Report No. (Pending E.R.C. Review)

Fast, A.W. 1973. Effects of artificial hypolimnion aeration on rainbow trout (*Salmo gairdneri* Richardson) depth distribution. Trans. Amer. Fish. Soc. 102:715-722.

Federal Energy Regulatory Commission. 1996. Draft Environmental Assessment for the Rock Creek – Cresta Hydroelectric Project, FERC Project No. 1962.

Federal Energy Regulatory Commission. 2004. Draft Environmental Impact Statement for Hydropower License, Upper North Fork Feather River Project – FERC Project No. 2105. September 2004. 395 p.

Gast, T. 2004. Prattville intake modification and potential impacts to Lake Almanor fishery study, interim report. Prepared for PG&E by Thomas R. Payne and Assoc. June 20, 2004. 32 p.

Hunter, C.J. 1991. Better Trout Habitat. Island Press. Washington D.C. 320 p.

Jones and Stokes. 2004. Draft simulation of temperature and dissolved oxygen in Lake Almanor, using the CE-QUAL-W2 water quality model. Prepared for PG&E.

Lee, R.M. and J.N. Rinne. 1980. Critical thermal maxima of five trout species in the southwestern United States. Trans. Amer. Fish. Soc. 109:632-635.

Leitritz, E. and R.C. Lewis. 1976. Trout and Salmon Culture. California Department of Fish and Game. Fish Bulletin 164. 197 p.

Moyle, P.B., B. Vondracek, and G.D. Grossman. 1983. Responses of fish populations in the North Fork of the Feather River, California, to treatments with fish toxicants. North American Journal of Fisheries Management 3:49-60.

Pfitzer, D. 1974. Tailwater trout fisheries with special reference to the southeastern states. Proceedings of the Wild Trout Management Symposium at Yellowstone National Park, September 25-26, 1974. p. 23-27. Trout Unlimited, Inc.

Pacific Gas and Electric Company. 1979. Application for license for Major Project – existing dam. September 26, 1979.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1982. Fish Hatchery Management. U.S. Fish and Wildlife Service. 517 p.

Scott, W.B. and E.J. Crossman. 1971. Freshwater Fishes of Canada. Fisheries Research Board of Canada. Bulletin 184. Ottawa, Canada. 966 p.

U.S. Fish and Wildlife Service. 1948 (revised). A report on fish and wildlife resources in relation to the water dev3elopment plan for the proposed Feather River Basin, Crock Creek and Cresta Projects (Power Project No. 1962). Report No. 1. River Basins Studies. 10 p.

U.S. Fish and Wildlife Service. 1962. Supplementary follow-up report for Rock Creek – Cresta project, FPC No. 1962, North Fork Feather River, California. Portland, Oregon. 12 p.

U.S. Forest Service. 1938. Report to the Federal Power Commission on the application of the Pacific Gas and Electric Company for a preliminary permit for the North Fork Feather River Project No. 1391 – California within the Lassen and Plumas National Forests. Regional Office – Region 5. San Francisco, California. Mimeo. 11 p.

Wales, J.H. and H.A. Hanson. 1952 (revised). The effect on the fishery of the North Fork of the Feather River, California, of proposed hydroelectric developments with special reference to Cresta and Rock Creek projects. California Department of Fish and Game. Mimeo. 19 p.

U.S. Forest Service. 1938. Report to the Federal Power Commission on the application of the Pacific Gas and Electric Company for a preliminary permit for the North Fork Feather River Project No. 1391 – California within the Lassen and Plumas National Forests. Regional Office – Region 5. San Francisco, California. Mimeo. 11 p.

Wales, J.H. and H.A. Hanson. 1952 (revised). The effect on the fishery of the North Fork of the Feather River, California, of proposed hydroelectric developments with special reference to Cresta and Rock Creek projects. California Department of Fish and Game. Mimeo. 19 p.