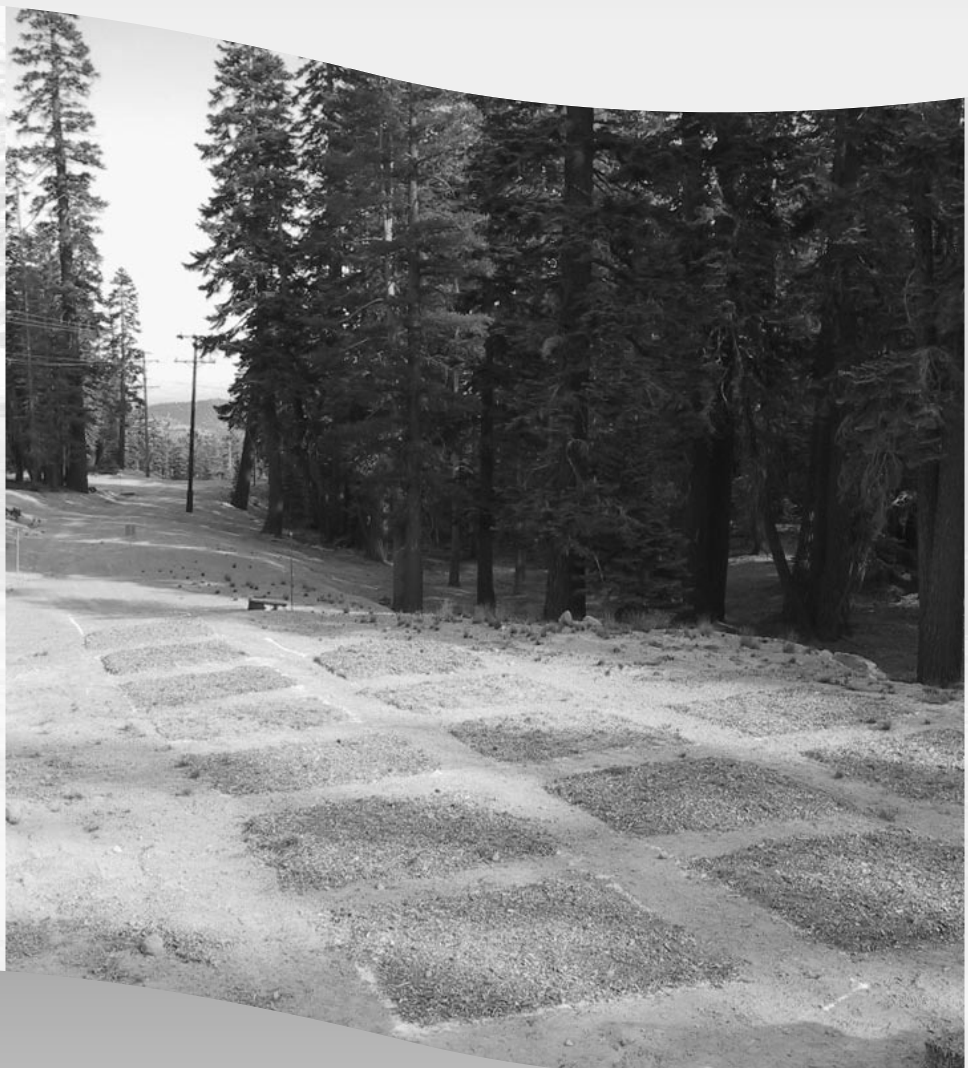
The California Alpine Resort Environmental Cooperative

presents

The Sediment Source Control Handbook

Preliminary Version – April 2005



Written by Michael Hogan,
Integrated Environmental Restoration Services

for The Sierra Business Council

in Cooperation with
The Lahontan Regional Water Quality Control Board

"All ethics so far evolved rest upon a single premise: that the individual is a member of a community of interdependent parts. His instincts prompt him to compete for his place in that community, but his ethics prompt him also to cooperate (perhaps in order that there may be a place to compete for). The land ethic simply enlarges the boundaries of the community to include soils, water, plants and animals or collectively: the land."

(Leopold 1949)

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Acknowledgements

The vision for the California Alpine Resort Environmental Cooperative (CAREC) emerged from ongoing discussions between Michael Hogan of Integrated Environmental Restoration Services, Martin Goldberg of the Lahontan Regional Water Quality Control Board and ski resort personnel. Many tensions over erosion issues between regulatory and ski area managers were due to the lack of good information on how best to control sediment in highly disturbed alpine areas. The idea to work together collaboratively to develop field trials was supported early by Harold Singer of the Lahontan Regional Water Quality Control Board, Amy Horne of the Sierra Business Council and a number of ski areas including Northstar-at Tahoe, Mammoth Mountain, Heavenly Lake Tahoe, and Alpine Meadows. With initial support from the Lahontan Regional Water Quality Control Board, a pilot program was launched to set up field plots and learn from different types of erosion-control treatments.

CAREC emerged from this pilot program as a collaborative partnership that includes representatives from ski resorts, Lahontan Regional Water Quality Control Board, US Forest Service, Tahoe Regional Planning Agency, consulting firms, Integrated Environmental Restoration Services and the Sierra Business Council. Time, resources, and technical input are all provided by the members plus outside 'experts' such as the Natural Resource Conservation Service (NRCS), the Nevada Resource Conservation District, and University of California Davis.

The key people who have worked throughout the pilot phase to help advance this program, install field trials, actively respond to earlier drafts of these pages, and commit to learning together about erosion control processes in disturbed alpine areas include:

Paquita Bath, Vice President, Sierra Business Council

Lou Cayer, Heavenly Ski Resort

George Cella, Lahontan Regional Water Quality Control Board

Todd Ellsworth, Ecologist, Inyo National Forest

Alex Fabbro, Planning Department, Mammoth Mountain Ski Area

Naomi Garcia, Environmental Scientist, TEAM Engineering & Management, Inc.

Martin Goldberg, Environmental Scientist, Lahontan Regional Water Quality Control Board

Melanie Greene, Scientist, Parsons Water and Infrastructure

Larry Heywood, Snow and Ski Safety Consultant

Michael Hogan, President, Integrated Environmental Restoration Services

Amy Horne, Research Director, Sierra Business Council

Eric Knudson, Squaw Valley USA

John Loomis, Director of Operations, Northstar-at-Tahoe

Erin Lutrick, Hydrologist, Inyo National Forest

Clifford Mann, Director of Mountain Maintenance, Mammoth Mountain Ski Area

Cadie Olsen, Trinity Environmental

Michael Schlaffman, Winter Sports Specialist, Inyo National Forest

Randy Westmoreland, Eastside Watershed Program Manager, U.S. Forest Service

Many thanks also to Karyn Erickson of the Sierra Business Council for the layout of this 2005 preliminary version of the Sediment Source Control Handbook.

Finally, developing collaborative programs that directly affect key businesses and water quality, requires a high degree of personal and institutional commitment. We acknowledge the commitment of all the CAREC team members to share their experiences, invest in experiments, and improve our understanding of sediment source control in ski areas throughout the Sierra Nevada.

I am grateful for the opportunity to work with this collaborative and serve as editor for this handbook. We look forward to continued cooperation on behalf of the Sierra Nevada.

Paquita Bath
Vice President
Sierra Business Council

Introduction to The Sediment Source Control Handbook

Sediment is a major water pollutant in the Western United States today. Wherever development takes place, disturbed areas are prone to sediment movement. Ski resorts are no exception. Large cut and fill, steep graded ski runs, can pose a serious threat to nearby waterways. Unfortunately, effective methods to control erosion for drastically disturbed alpine areas have not been well researched or documented. Despite a long list of 'BMPs', or recommended 'best management practices', attempts to stabilize disturbed alpine areas continue to produce inconsistent results.

To date, there has been little effort to develop a systematic approach — with specific goals, documented procedures, and ongoing monitoring — to control erosion in ski resorts. Projects are undertaken in a trial and error fashion, sometimes resulting in successful outcomes, and sometimes producing less than optimal results. While there is a broad range of knowledge across resorts, information sharing has been limited.

The California Alpine Resort Environmental Cooperative (CAREC) came together in 2003 to develop a process for planning and implementing erosion control projects and to experiment, through field plots, with various approaches to control sediment on site and thus reduce erosion. The purpose of the partnership is to use field plots to develop on-the-ground practices to better manage erosion and maximize sediment source control on ski area properties. The underlying philosophy is that a collaborative approach between land managers, field practitioners and regulators is the best way to develop an effective, functional and workable set of practices that parties can adapt to fit their needs while greatly enhancing their ability to control sediment in ski areas.

The group meets two to three times a year to share field trial results and challenges. CAREC uses an adaptive management process to plan, implement, and measure erosion control projects and then share information with other practitioners and regulatory personnel. This 2005 Handbook expresses the preliminary approaches and findings of an ongoing program to document cost effective and measurable improvements in sediment source control practices in Sierra ski resorts. The Handbook is made up of three sections:

Part I: Guiding Principles – provides an adaptive management approach to planning and implementing erosion control projects;

Part II: Technical Notes – describes treatment approaches as a starting point for developing better practices, procedures, and monitoring protocols.

Part III: Literature Review – references appropriate information for planners, practitioners, monitoring personnel and scientists involved in upland sediment source control projects.

Thanks to the State Water Resources Control Board, this pilot project will grow to incorporate field trails in at least six different ski resorts and substantial monitoring of sediment source control. An updated version of the Sediment Source Control Handbook, will incorporate monitoring results and CAREC's improved ability to control sediment in 2008.

Sierra Business Council

The Sierra Business Council (SBC) is the only membership-based regional organization devoted to securing the social, natural, and financial health of the incomparable Sierra Nevada. Founded in 1994, the award-winning SBC achieves its mission through leading-edge research & publications, on-the-ground programs and fee-for-service, and grass roots membership and community networking. Business, government, non-profit, and civic leaders use SBC to meet, share-ideas, gain access to resources and expertise, and put plans into action. Partnering with local communities, and in partnerships such as the California Alpine Resort Environmental Cooperative (CAREC), the Sierra Business Council helps communities plan for and achieve their visions for the future.

SBC is entering its second decade as an award-winning, regional business organization. In response to the enormous challenges facing the region, the Sierra Business Council helps Sierra communities work together to steer the region's economy, environment and communities in directions that ensure long-term prosperity. Recent accomplishments include:

- Being chosen by Governor Arnold Schwarzenegger for his prestigious 2004 Environmental and Economic Leadership Award.
- Developing the bipartisan coalition behind the landmark Sierra Nevada Conservancy bill, signed by the Governor, which invests in our natural, cultural, and historic assets.
- Training business and civic leaders in our world-class Sierra Leadership Seminar to improve individual professional skills while enhancing the civic infrastructure of our region.
- Securing funding for the Town of Truckee to explore development of a railyard brownfield to extend the vibrant downtown;
- Convening hundreds of Sierra business and civic leaders to address critical topics such as affordable housing, fostering creative communities, and the state of the Sierra.
- Publishing award-winning research documents like the *Sierra Nevada Wealth Index*, *Planning for Prosperity*, and *Investing for Prosperity* that are used every day to build sustainable wealth in our region.
- Partnering with the Edward Lowe Foundation to provide our members business and entrepreneurial resources plus a new SBC e-News & On-Line Networking tool.
- Developing a partnership of ranchers and conservationists to maintain ranching as a fundamental part of the Sierra's economy and landscape – conserving over 30,000 acres of working ranchland in the Sierra Valley;

SBC is proud to provide programs, research and documentation, such as the *Sediment Source Control Handbook,* that can stimulate residents and decision makers to work together to ensure that the Sierra Nevada remains one of the most desirable places to live, grow a business, and raise a family. The CAREC partnership will be expanded between 2005 and 2008 to ensure that our knowledge and understanding of sediment source control on steep alpine slopes continues to improve.

***For more information on the Sierra Business Council or to become a member, please visit www.sbcouncil.org*.**

The California Alpine Resort Environmental Cooperative

Sediment Source Control Handbook Part II

Technical Notes

Preliminary Version – APRIL 2005

Written by Michael Hogan,
Integrated Environmental Restoration Services
for The Sierra Business Council
in Cooperation with
The Lahontan Regional Water Quality Control Board

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INTRODUCTION TO TECHNICAL NOTES

The California Alpine Resort Environmental Cooperative (CAREC) came together in 2003 to develop a process for planning and implementing erosion control projects and to experiment, through field plots, with various approaches to control sediment on site and thus reduce erosion. As part of the Sediment Source Control Handbook, the group wanted Technical Notes that would provide detailed explanations for land managers to select appropriate treatments. Ultimately, the idea is that there will be detailed Technical Notes that provide more in-depth information for every Guiding Principle. This April 2005 preliminary version of the Technical Notes will be modified repeatedly over the next three years in consultation with the CAREC team, to make them as useful as possible to ski area land managers.

A great deal remains to be learned about the control of erosion and the establishment of a sustainable plant-soil system that is capable of controlling erosion and sustaining a robust plant community. Many of the so-called BMP's or "Best Management Practices" in use today have either been inadequately tested and researched or are not correctly implemented (improper installation or lack of site specificity.) This situation poses both a challenge and set of opportunities to land managers and regulatory agencies alike. These Technical Notes are intended to describe key treatment approaches as a starting point towards developing better practices, procedures, materials and monitoring protocols. For references cited please see the Reference List in the Literature Review (Handbook Part III).

CALIFORNIA ALPINE RESORT ENVIRONMENTAL COOPERATIVE
SEDIMENT SOURCE CONTROL HANDBOOK PART II

DRAFT TECHNICAL NOTE 1

ASSESSING SITE CONDITIONS

Description

To assess site conditions, information is gathered from a project area to understand the nature and character of the site. This information is gathered before a project is initiated, during implementation, and after a project is completed. The information can be used for project planning and project tracking and monitoring.

Site assessment should gather as much information as needed to adequately understand the site. Types of information typically gathered include: site physical characteristics such as slope angle and aspect; solar exposure; soil type; soil density; surface cover; site location (lat-long - GPS coordinates); and directions to the site. Site biological information often includes: soil type; nutrient levels; soil texture; vegetative community; soil moisture; etc. A standard CAREC form is included in Technical Note 2: Site Assessment Baseline Information.

Adequate site assessment lays the groundwork for deciding what sorts of treatments and materials are needed to achieve project goals. For instance, if a planner does not know the nutrient level in the nearby soil and in the disturbed soil, it will be impossible to accurately specify the amount of material needed to replenish nutrient levels in the treatment area. Thus there will be a tendency to over or under estimate amounts of fertilizers or soil organic amendments. When the appropriate information is collected and USED, whether and why a project is or isn't functioning as intended, can be better understood.

Appropriate uses, applications

Site assessment is important on every project. Different projects require different levels of site assessment from basic for small projects to more in-depth assessment for complex, large projects.

ALTERNATIVES

Table 1.1: Types of Soil Physical Assessment

Type	**Analysis**
Site Physical Assessment	Useful for getting a physical understanding of the site and exact location. This information includes such things as slope, aspect, soil type, location and so on.
Soil Nutrients	Critical to understand how much and what types of amendments may be needed.
Soil Density	Important key to understand the soils ability to infiltrate and store water. This assessment will suggest what type and how much soil physical preparation will need to take place.
Solar Input	The amount of sun that reaches a site each day influences vegetation and evapo-transpiration. Solar input can be measured by a number of devices. A Solar Pathfinder (*www.solarpathfinder.com)* is used to site houses for either active or passive solar systems. For our purposes, the higher the solar input, generally, the higher the evapo-transpiration from a site and thus the less available water in the soil.
Soil Moisture	Soil moisture data, when compared to other similar sites, will help the planner to understand whether this soil is able to hold adequate water or whether additional irrigation, organic matter or mulching will be needed to reach the required moisture levels in the soil.
Other	There are a great many assessment protocols that may be used. The main criteria should be the NEED for the information and the usefulness of that information to the planning, implementation and monitoring or tracking process

Table 1.2: Types of Monitoring/Assessment

Type of assessment	Analysis
Baseline or Pre-assessment	Used to gain an understanding of existing conditions, to specify the appropriate amount of materials or treatment to use and as a reference for follow-up monitoring. See Technical Note 2.
Implementation Monitoring	Used to assess whether actual application matches specifications or plans. This should be done with ski area crew or with outside contractor. This type of monitoring attempts to answer the question "Are we getting what we're paying for?"
Performance Assessment or Monitoring	This type of assessment, also called 'functional monitoring' (is it functioning correctly?) is used over time following project completion and should be done for at least 3 or more seasons. Specific parameters monitored will depend upon the project scope, purpose, requirements and budget.
Water Quality Monitoring	Water quality monitoring is not covered in this document. Water quality monitoring may, or may not, provide a direct link to erosion control project performance.

CALIFORNIA ALPINE RESORT ENVIRONMENTAL COOPERATIVE
SEDIMENT SOURCE CONTROL HANDBOOK PART II

DRAFT TECHNICAL NOTE 2
GATHERING BASELINE INFORMATION

Description

Site assessment-baseline information has two main purposes: 1) to collect information that will help the project planner gain a more complete understanding of site parameters (see Technical Note 1: Assessing Site Conditions); and 2) create a standardized input format for database information gathering in order to more easily track project info, especially baseline info (what the site was like before treatment). The purpose is to use the information to better understand project outcomes.

For example, if we apply a soil-revegetation treatment, it's difficult to interpret that outcome without knowing what that site was like prior to treatment. When we revisit a site a year or more following treatment, it is difficult to remember what was done. This form lays the foundation for data interpretation.

Appropriate Uses, Applications

All project sites should have some base level of project site information collected. This information will be the basis of as-built documents as well.

Form Description

The following fields are suggested as a standard, basic format. Some projects will gather additional information. This form is designed to be simple to use and can be done in a very short period of time. Complete information should take less than one half hour to complete, with additional data gathering such as soil sampling and vegetation/cover assessment taking longer to complete.

SITE ASSESSMENT DATA SHEET

Company, name, title of person doing site assessment:

Project name:

Date:

Location description:

Location coordinates (Lat-long/GPS points):

Purpose of project:

Landscape information:

Slope:

Aspect:

Elevation:

Soil parent material:

Landscape position (upland, meadow or flat, riparian, wetland):

Landscape shape: (concave, convex, undulating, etc.)

Level of current disturbance: (none, low, moderate, high [construction projects would likely rate as high])

Photo points taken? Y__ N__

Photo point locations (GPS Coordinates and compass direction)

GPS-lat long _____________ Compass direction (degrees)________________

Project map or drawing attached?

Cover (plant and mulch) assessed? Y___ N____

Type of assessment (Visual estimate, measured)

Cover %: Plant _____ Mulch ______

Number of soil samples taken?

Soil sample location map attached?

Soil density measured (cone penetrometer, other):

Overall site condition prior to construction or treatment (disturbed, native, well or poorly vegetated):

Type of project to be constructed:

Construction contractor or implementer:

Erosion control treatment foreman and personnel:

Dates erosion control implemented:

General description of erosion control measures implemented:

As-builts of erosion control attached?

CALIFORNIA ALPINE RESORT ENVIRONMENTAL COOPERATIVE
SEDIMENT SOURCE CONTROL HANDBOOK PART II

DRAFT TECHNICAL NOTE 3
SOIL PHYSICAL PREPARATION

Description

Soil physical preparation consists of breaking up or loosening the soil to increase water infiltration, root penetration, aeration and nutrient movement. Physical preparation is generally done on highly compacted or otherwise dense soils.

Drastically disturbed sites, such as road cuts, ski runs and construction sites, often have high levels of compaction and high-density material, usually a result of construction activities. Road cuts in the Sierra Nevada for example, usually consist of dense subsoil or parent material. Compaction and high bulk density result in negative impacts on soil, plant growth and ultimately erosion from that site. Soil physical treatment is used to de-compact the soil to allow increased infiltration, root penetration, gas exchange and aeration for both plants and microbes.

Opinions vary as to the recommended depth for soil loosening. Twelve inches is currently the standard, representing a trade-off between ecological/hydrologic benefits and costs. Given a compacted soil of 20% pore space, calculations suggest that for each additional inch of tilling, the soil will be able to hold an additional 0.31 gallons per square foot. So the difference between 6 and 12 inches over an acre would be 81,675 gallons of water potentially infiltrating into the soil and/or stored in the soil as water for plant growth. Thus, the two main benefits of soil preparation, beyond the effect on plant growth, are increase in infiltration and the associated decrease in runoff as well as the increase in the amount of water stored.

Soil physical treatment includes tilling, ripping, turning soil over or the use of infiltration tines to open and loosen dense soils without turning them over. The latter technique is used on a steep and/or unstable slope where massive disruption of the soil 'strength' may result in a mass-type of soil movement.

Physical treatments are often combined with applications of soil amendments such as compost or aged wood chips in order to incorporate materials to a specific depth as tilling or ripping is done. Table 3.1 lists a number of treatment types.

Appropriate Uses, Applications

Soil physical treatment is used wherever soil density is high enough to limit plant growth and infiltration. The best way to determine whether the soil is artificially dense is to measure density on a native or highly functional site as a reference. No standards have been set relative to what is 'acceptable'. However, if density is 20 or more percent higher than the native site, it is advisable to apply some sort of soil physical treatment. As more information is gathered from ski areas regarding this critical issue, better guidelines will be developed.

ALTERNATIVES

Table 3.1: Soil Physical Treatments

Alternative	**Analysis**
Machine Tilling	Machine tilling includes soil loosening by backhoe or hoe-equipped excavator. This type of tilling completely mixes the soil and any amendments that are placed prior to tilling, allowing for a more consistent break up of dense soil. The potential drawbacks include destabilizing very steep slopes. In some cases, access is difficult for backhoes and excavators. In cases of very steep slopes, tilling can be done with a reach forklift or other mechanical means. However, when steep slopes are tilled, it is essential to establish plants immediately in order to stabilize the slope with plant roots. Tilling applications can be extremely cost effective if access is good.
Rototilling	Rototilling involves turning over the soil using a rotary tine attachment on either a hand operated machine or a tractor. Typically, in mountainous soils, rototilling is of limited usefulness due to the rocky nature of the soils. Rototillers can penetrate up to 4-6 inches, depending on the nature of the soil.
Ripping	Ripping uses ripper shanks to penetrate, decompact, and loosen the soil. Ripping is usually faster than tilling but is not always as complete for mixing. Since ripping is done by tractor-mounted attachments, slope angle can be a limiting factor for where ripping can take place. Winches can be used to extend the areas where ripping can take place.
Hand Tilling	Hand tilling is used where machines are not available or cannot reach. Hand tilling is limited by how deep hand tools can go and the enthusiasm of the hand labor crew. Typically, six inches is the limitation of hand tilling depth.
Auguring/Drilling	Auguring and drilling is utilized on very steep slopes where other methods of soil loosening would tend to destabilize the slope. Drilling is done such that the native stability of the soil is maintained. Holes are drilled on 6, 12 or other centers to ensure that a general level of stability is maintained. Drilling allows soil amendments, water, and plant roots to penetrate down into channels, thus encouraging some level of plant growth and infiltration/water storage. In many cases, drilled areas need to be irrigated for one or two seasons. Irrigation MUST be done infrequently and deeply so that water can penetrate down into the channels, thus encouraging roots to follow the water. Shallow irrigation will result in shallow roots, thus defeating the purpose of drilling.

KNOWN OR MEASURED OUTCOMES

- Increase in infiltration and thus runoff. In some cases, soil treatment has produced measured infiltration rates of over five inches (5”) per hour.
- Increase in water holding capacity and thus reduction in need for irrigation
- Increase in organic matter content and nutrient cycling, if combined with organic matter application.
- Increase in oxygen exchange through the soil, which is a key element of both microbial activity and disease suppression.

SUGGESTED SUCCESS CRITERIA

Low soil density to specified depth. i.e. resistance to force no greater than 200 psi to a depth of 12 inches using a cone penetrometer.

MEASUREMENT METHODS FOR SUCCESS

Cone penetrometer, infiltration measurement device (many available)

MANAGEMENT RESPONSE TO LACK OF SUCCESS

Re-treat to adequate depth

SUGGESTIONS FOR FURTHER ACTIONS OR INFORMATION NEEDED

- We need more information on a range of infiltration rates given specific types of treatment and different types of soil. In the next few years, CAREC will be using rainfall and runoff simulations to gather more of this information.
- More information on the respiration response of various types of treatment needs to be developed.

CALIFORNIA ALPINE RESORT ENVIRONMENTAL COOPERATIVE
Sediment Source Control Handbook Part II

Draft Technical Note 4
Fertilizers

Description

A fertilizer is any material that adds nutrients to the soil usually with the intention of supporting or increasing plant growth. Fertilizers range from mineral fertilizers such as ammonium nitrate (NH_4-NO_3), or other mineral nitrogen forms, to a number of organically derived materials. The difference between fertilizers and soil amendments is sometimes indistinct, in that some soil amendments have a nutrient content and thus act as fertilizers (delivering nutrients to the soil), and some fertilizers actually change the soil physical make up and thus act as soil amendments. In fact, most 'soil amendments' will provide some nutrient input and thus fill two functions.

Mineral fertilizers, especially those known as 'nitrogen' fertilizers, are largely synthesized from atmospheric nitrogen. Mineral fertilizers contain most of their nutrient load in an available form. This is important to know in that available minerals, especially N, tend to be highly mobile and thus are prone to leaching and do not tend to persist. Therefore, if mineral fertilizers are used, they must be applied frequently to be effective. An exception to this rule is the case of the slow-release, usually coated fertilizers. This type of fertilizer is a class of mineral fertilizers that are coated with a polymer or other material so that the release rate can be controlled.

Organic fertilizers derive some, or all, of their nutrient load from organic sources. There is some discussion of what 'organic' means. Chemically speaking, an organic compound is anything that contains carbon molecules. Thus, at least one fertilizer that claims to be organic is derived from lignite, a coal-based product and is then mixed with urea for its nitrogen source. At the other end of the organic spectrum there are fertilizers that have undergone the rigorous scrutiny of organic certification programs such as CCOF *www.ccof.org* or Oregon Tilth *http://www.tilth.org/site/*. These products are derived from clean, non-GMO (genetically modified organisms) organic sources and must be free from specific chemical residue. Between these two extremes exist the most common organic fertilizers such as manures, various 'compost' materials and others.

Not all organic fertilizers act the same or perform with the same nutrient release rate. It is important to understand as much as possible about the particular material you are using so that it will meet project objectives. For instance, if you were applying a soil-revegetation treatment in the fall, and used a mineral, highly mobile fertilizer, that fertilizer would likely be gone in the late spring when most plant growth occurs. In this case, it would be better to apply that fertilizer in the spring when plants begin to grow and can access the fertilizer.

Appropriate Uses, Applications

Given the range of fertilizer types available, we list several web sites where information has been posted.

Use of a particular fertilizer should be linked to the need and the release rate of that fertilizer. If rapid nutrient release is desired, mineral fertilizers should be used. If a slightly slower application is needed, an organic or coated mineral fertilizer may be more appropriate. In other words, plant and soil needs and fertilizer should be matched. Over or under application or application of improper material is likely to be inefficient both economically and environmentally.

ALTERNATIVES

Table 4.1: Fertilizer Information Resources

Alternative	**Analysis**
http://www.fertilizer.org/ifa/	International Fertilizer Industry Association
www.calfertilizer.org/	California Fertilizer Industry Association
http://www.ext.vt.edu/departments/envirohort/factsheets2/fertilizer/jan89pr6.htm	University of Vermont Extension; good explanation of types of organic fertilizers
Anrcatalog.ucdavis.edu/pdf/7248.pdf	UC Davis publication about organic fertilizers for crops. Good general information

KNOWN OR MEASURED OUTCOMES

The outcome of fertilizer use should be adequate plant growth and little soil nutrient loss. Nutrient loss is difficult to measure. Adequate plant growth may be subjective, but if success criteria are developed for plant cover or density, those criteria can address whether the plant growth is 'adequate'.

MEASUREMENT METHODS

Soil tests are used to determine the amount of nutrients that are present in a particular soil. Take soil samples in adjacent native or undisturbed areas and compare that to the treatment area. Soil sample interpretation requires skill and experience, especially in the project area. Soil labs typically interpret results from an agricultural perspective, which can be misleading. Agricultural systems require one or more applications per season whereas revegetation projects in ski resorts typically utilize one-time applications, though some resorts have developed follow-up programs.

MANAGEMENT RESPONSE TO LACK OF SUCCESS

Additional applications may be appropriate. However, usually lack of success may be due to an improper matching of the plant-soil need to the fertilizer. A useful management response may be to determine the nutrient level of the soil and match that to the fertilizer.

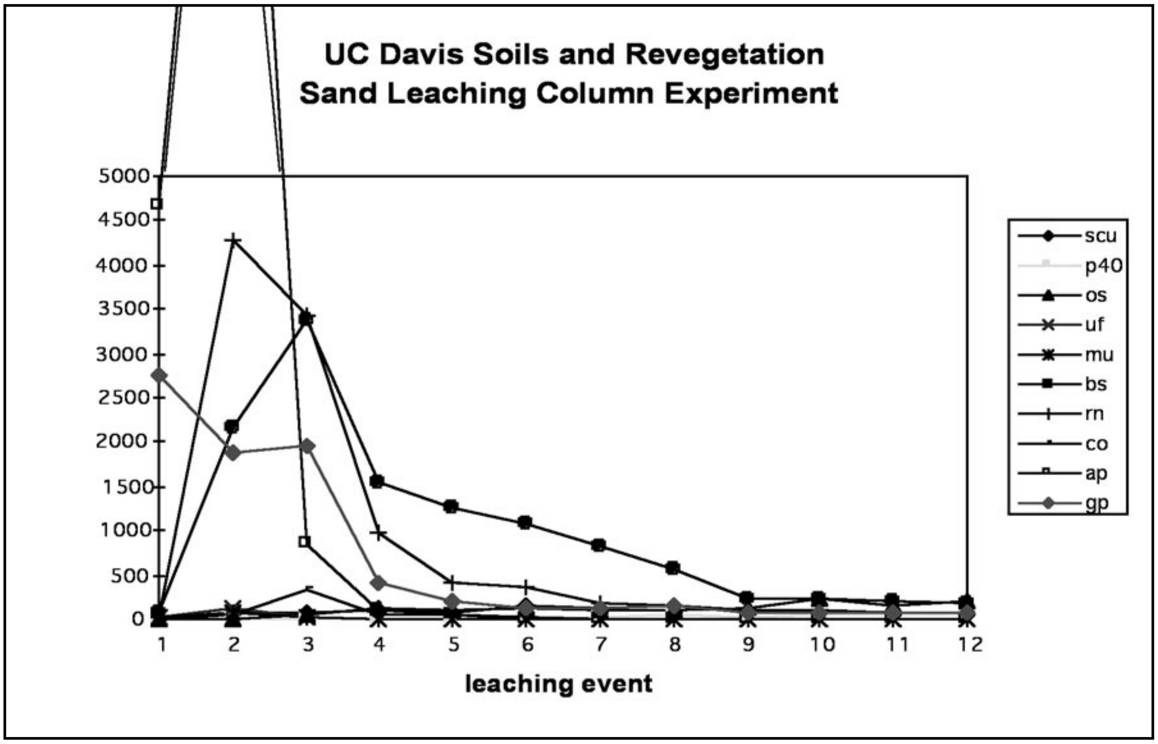

Figure 4.1: Leaching data for a number of mineral and organic fertilizers. The Y axis represents leaching events (water leached through a sand column containing one form of N-containing fertilizers or soil amendments). The X axis represents the amount of N leached from the sand column. Some fertilizers release most of their nitrogen in 3 leaching events whereas others deliver N over a much longer period of time. This information suggests that release rate must be matched with need. Further, some fertilizers, such as 'ap' (ammonium phosphate) may present a runoff and pollution threat if not absorbed by plants immediately. From Claassen and Hogan 1998.

CALIFORNIA ALPINE RESORT ENVIRONMENTAL COOPERATIVE

SEDIMENT SOURCE CONTROL HANDBOOK PART II

DRAFT TECHNICAL NOTE 5
SOIL AMENDMENTS

Description

Soil amendments describe any number of materials that are used to enhance soil physical or biological properties, such as water retention, permeability, water infiltration, drainage, aeration and structure. Soil amendments may consist of organic fertilizers (covered in the 'fertilizer' technical note), compost, tilled-in wood chips, mycorrhizal inoculum, or any number of other materials that are used to improve some element of the soil. Many soil amendments also contain nutrients and thus may be considered 'fertilizers', playing dual roles in soil treatment.

Appropriate Uses, Applications

Soil amendments are widely used and recommended for any number of situations where soil has been disturbed. Often, soil amendments are used without adequate understanding of exactly what is missing in the soil or without proper understanding of the potential and limitations of the amendment. In order to specify and apply the appropriate amendments, soil and plant conditions should be assessed (See Technical Notes 1 and 2) and the need for a particular amendment determined.

Perhaps the most widely useful soil amendment is compost[1]. Typically, in ski run construction or other 'drastic' disturbance, most of the organic topsoil layer is buried or removed. Once it is diminished or removed, the physical and biological functions needed to support the soil-plant system are severely impacted. In order to restore that these functions for the long term, organic matter will usually need to be added. In many cases, organic fertilizers or other amendments such as mycorrhizae are added with the belief that those additions will effectively 'restore' the system. However, if one assesses the amount of nutrients and organic matter that have been removed and compare that to the amount that is needed, it becomes clear that the addition of fertilizer or mycorrhizae is unlikely to replace the amount of nutrients or microbial activity needed for robust, sustainable erosion control.

For example, if 2000 pounds of an organic fertilizer with 6% nitrogen (N) was added to a site, that would provide the site with 120 pounds of actual N. The amount and form of N is likely to be inadequate to effectively recapitalize that site or support robust plant growth over an extended period of time. It has

[1]See additional websites on compost:
www.woodsend.org; *http://tmecc.org/sta/compost_attributes.html; http://www.epa.gov/epaoswer/non-hw/muncpl/comppubs.htm; http://attra.ncat.org/attra-pub/altsoilamend.html#soil*

been established that at least 1200 pounds of organically-bound N is needed for robust plant growth in the Tahoe Basin (Claassen and Hogan 2002). The type of N in organic fertilizers is generally of a much faster release rate and would likely be used up or leached from the system in 2-3 seasons.

On the other hand, composts tend to have a much lower N release rate albeit they vary widely. Figure 1 shows a graph derived from N release data from four types of compost. Two composts release a robust amount of N in a short period of time and then slowly release the remainder over time. However, two other types of compost actually lock up N, making it unavailable to plants for some period of time. While all of these 'composts' contain N, two would actually improve plant growth while two would diminish plant growth unless additional, more available N were added. Thus it is critical to understand what is in the soil in order to know what and how much to add to the soil.

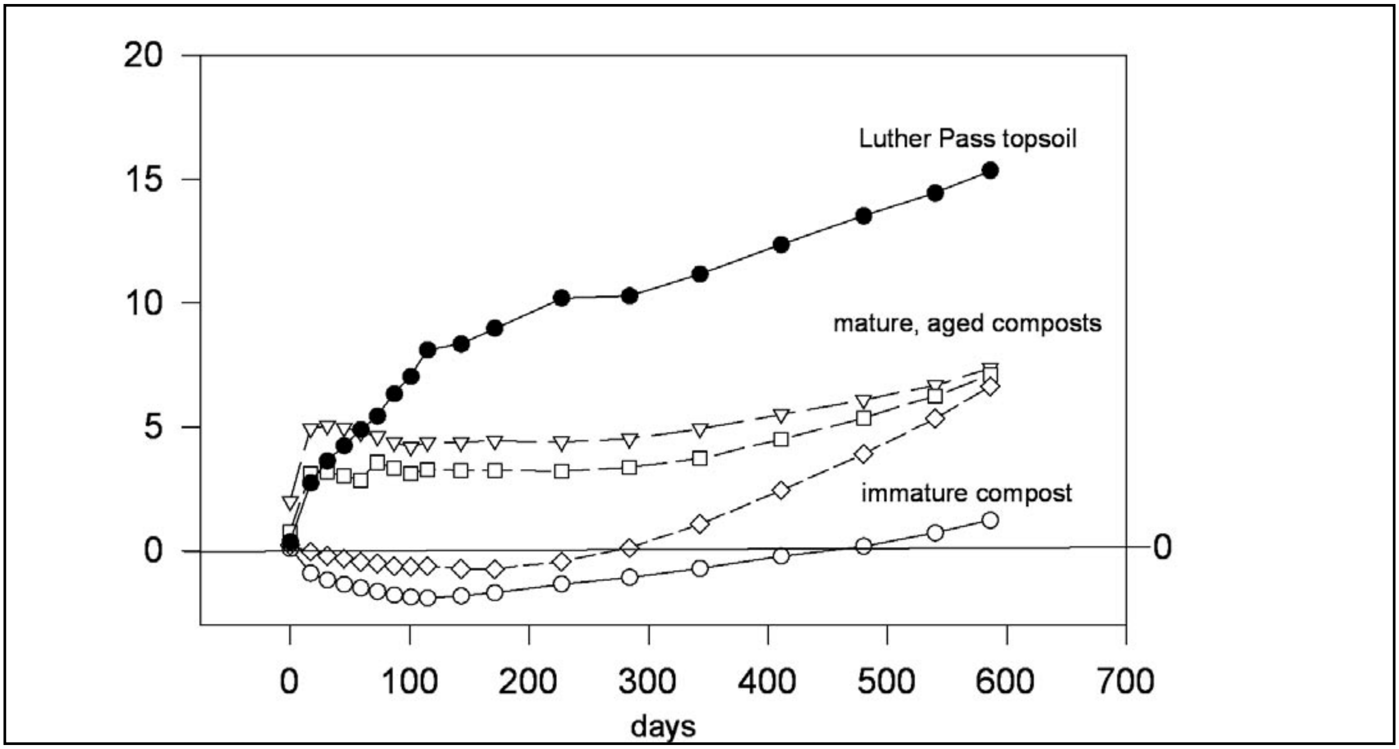

Figure 1 shows the differences in compost N release over time. This figure indicates the importance of matching the appropriate compost or soil amendment to a specific site condition. For instance, the immature compost actually removes or locks up nitrogen, and thus would tend to reduce or eliminate plant growth whereas the mature compost releases a much greater amount of N for plant growth (see Claassen and Hogan 1998).

ALTERNATIVES

Table 5.1: Alternative Soil Amendments

Alternative	Analysis
Compost	The term "compost" is used to describe a number of materials derived from the breakdown of organic matter. Unfortunately, there is little commonly accepted definition of compost material. To that end, the US Composting Council (USCC) has produced the following definition: Compost is the product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and Processes to Further Reduce Pathogens (PFRP), as defined by the US EPA (Code of Federal Regulations Title 40, part 503, Appendix B, Section B) and stabilized to the point that it is beneficial to plant growth. Compost bears little physical resemblance to the raw material from which it originated. Compost is an organic matter source that has the unique ability to improve the chemical, physical and biological characteristics of soils or growing media. It contains plant nutrients but is typically not characterized as a fertilizer"(USCC, Field Guide to Compost Use). • Organic additions such as aged manure, aged wood chips, and a broad range of other materials, can be used as organic amendments. However, it is difficult to know what effect they will have on the soil without adequate testing. Some materials may not have the desired effect, others may have a greater effect than desired (for instance, excess N or P). The use of the above definition of compost will at least allow us to use the same term for a similar product. • One word of caution regarding using compost: some municipal composts are made from sewage sludge and even though this material is approved in some agricultural and forestry settings, this sludge derived material can contain a great deal of available N and potentially some heavy metals and pathogens. Before using ANY compost, it is important to know what it was made from and whether application of that material is approved by the local water quality control agency.
Organic Fertilizer	The term organic fertilizer covers a broad spectrum of materials from chicken manure to lignite/ammonium combinations. There are few standards to define an "organic" fertilizer. Materials approved for organic farming set a higher standard. Some organic fertilizers may contain a great deal of available nitrogen and phosphorus, thus creating a tendency toward leaching or nutrient runoff. Other fertilizers may contain residual toxins, introducing unwanted materials into the soil. For instance, one "organic" fertilizer has been banned by the Wyoming Department of Transportation because of the potential to import residual pathogens from the source - chicken manure. When choosing an organic fertilizer, it is useful to understand the relative release rate of the nitrogen and the amount of especially N and P needed, as indicated by soil tests.

Table 5.1 (cont): Alternative Soil Amendments

Alternative	Analysis
Mycorrizal Inoculant	Mycorrizal inoculant is intended to re-introduce a type of fungi into the soil that is an important element for plant growth in many types of plants. Mycorrizal inoculants are available from a number of producers or can be collected from native areas. The effectiveness of these amendments is the subject of a great deal of study and debate (see literature report).
Soil Conditioners	Soil conditioners are used to change or enhance a physical component of the soil. For a complete discussion of soil conditioners, see: *http://attra.ncat.org/attra-pub/altsoilamend.html#soil*
Seaweed Products	Seaweed products are added to a soil or compost pile to increase N and other minerals. Seaweed products may contain salts that can be harmful to plant growth.
Humates	Humates or "humic acids" are intended to mimic the "active" part of soil humus. The sheer volume of organic matter in moderately rich soils suggests that agronomically affordable applications of humates may not produce significant improvements. The top six inches of soil weigh approximately 1,000 tons per acre; each percent of organic matter, therefore, weighs ten tons. Even assuming that the organic matter in humate products actually is similar to that in soil, it requires two tons of humates per acre to increase soil organic matter by 0.1%.

Known or measured outcomes

Given the broad spectrum of soil amendments, it is difficult to suggest specific measured outcomes. However, anticipated outcomes for each soil amendment type should be listed by the supplier, and/or the planner. For instance, if the supplier suggests that mycorrhizae will increase plant growth, ask how much or by what measure. In that way, we can assess whether claims are actually borne out in high alpine conditions and whether the treatment is cost effective.

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SEDIMENT SOURCE CONTROL HANDBOOK PART II

DRAFT TECHNICAL NOTE 6
PLANT MATERIALS

Description

Plant materials include any live or potentially live materials such as seedlings, transplants, or seeds, used to enhance an erosion control or landscaping project. The selection of plant material should be considered relative to the specific function needed within an erosion control project. For instance, plants roots provide an important function in holding soil together and providing soil strength. Plants also provide mulch when they are mature enough to produce excess leaf material. Plant leaves provide cover over the soil, thus protecting soil from raindrop impact.

Functions associated with each individual plant type must match the need of the erosion control project. For instance, many grasses grow quickly and establish a plant community that can tie the soil together, produce surface mulch and help bootstrap the soil nutrient cycle. At the same time, some grasses are invasive or persistent while others die out in a few seasons. Seedlings of shrubs and trees provide greater root penetration and additional erosion control, but may not provide much protection for several years due to their slow growing habits.

The actual erosion control 'service' provided by each plant type should be carefully considered. The presence of grasses (or other plants) on a site does not necessarily assure that site of being erosion free. The ability to hold sediment is based on a number of elements including infiltration, mulch cover, adequate soil organic matter, and so on. Plants are one component of that system and are not the sole determinant of erosion. Plants should be selected in the context of the entire system within which they function.

Native vs non-native: Some ski areas, especially those on US Forest Service land, are required to use solely native species. Others may choose to do so or opt for adapted species. There are no clear-cut parameters for choosing native vs non-native in a strictly erosion control context. However, each type has its strengths and weaknesses. Historically, non-native grasses were used due to the belief that natives were more slow growing. However, recent experience has shown that some native grass species, such as Bromus, Elymus and others, grow as fast as most of the adapted species. It is also commonly believed that native plants can thrive on nutrient poor soils. This has been shown to be erroneous.

Native vs native: Another consideration when choosing a native species is whether it is genetically indigenous or simply the same species. For instance, *Elymus elymoides* (Bottlebrush Squirreltail) grows from the California coast to the upper elevations of the Sierra Nevada and across the Great Basin. However, the genetic makeup, and thus growth habits and preferences of the same species growing in different locations, vary broadly. If native species are used, it is suggested that local genotypes be selected. There is some concern that local gene pools may become 'polluted' or weakened by non-local genotypes. Beyond the genetic considerations, locally collected plant material will usually perform better than material from a different climate and altitude.

Weed free seed: Seed should be specified as weed free since even native seed, when field grown, can introduce weeds. Weeds, introduced in seed mixes or straw mulch, can become established and crowd out more useful species. Some weeds, such as Tall Whitetop (*Lepidium latifolium*) can be extremely invasive.

Pure Live Seed (PLS): The concept of pure live seed is extremely important in the ordering and application of seed to a project. PLS is the amount of seed that can actually be expected to grow within a batch of bulk seed. All seed should be tested within the past year. Tests will indicate how much of the material in the seed bag is actually seed (some material may be 'fluff' or "chaff" or other material). Some of the seed itself may not be viable. Seed testing determines the amounts of non-seed and non-viable seed and is usually reported as 'impurities' and 'viability'. So if 20% of a 50 pound bag of seed is made up of impurities and non-viable seed, then only 40 pounds of that bag contains seed that can be expected to grow. Therefore, if one needed to apply 40 pounds per acre, 50 pounds of bulk seed would be required. It is important to always order and specify seed as PLS. For instance, if a seed supplier had an old bag of seed in which only 10 percent was viable and you applied 100 pounds per acre, you would only be putting 10 pounds of actual live seed on that acre – a guaranteed poor plant response rate.

Appropriate Uses, Applications

Plant type, growth habits and aesthetic value should be matched to the project goals. For instance, if erosion control was the main goal, one may not choose seedlings as the first line of defense since seedlings usually do not develop significant root structure or canopy cover for a number of years. A great deal of work remains to be done on how a range of native shrub and tree species seeds can be used successfully in erosion control projects.

ALTERNATIVES

Table 6.1: General Assessment of Various Plant Types, Forms and Habits

Alternative	Analysis
Grasses	Quick growing, usually fiberous root structure. Grasses require moderate to high amounts of water. Some grasses are better as scavenging water than others (Elymus elymoides, for instance).
Forbs	Some are quick growing, add to aesthetic of a site; difficult to get native seed.
Shrubs	There are a broad range of shrubs available. Some research is required to determine habits, requirements, etc. Shrub seedlings usually require some supplemental irrigation in the first season. Possibly the most effective means of choosing the proper shrubs is to contact the local nursery, especially if they deal with native plants.
Trees	Very slow growing - of limited use in ski areas.
Seed vs seedlings	Seed is usually most appropriate for grass establishment. Shrubs and trees may be established more quickly by planting seedlings. However, seedlings (live plants) are much more expensive to install. More work needs to be done on the ability of many plants to grow from seed. Native plants demonstrate a range of response to direct seeding due to cause and effect relationships such as soil type, nutrient level, mulch depth, solar radiation %, and other factors that affect germination. Germination triggers are not always known, or when known– as with fire, may not always be available.

KNOWN OR MEASURED OUTCOMES

APPLICATION

Seed: seed should be very lightly raked into no more that 2x the diameter of the seed. Some seed prefers to lay on top of the soil. Particulars should be given by the seed supplier.

Seedlings: General procedures include soil preparation, adequate planting hole size, supplemental irrigation, mulching.

SUGGESTED SUCCESS CRITERIA

For grasses, a cover percent (e.g. 40% of treatment site covered within 2 years). For shrubs, a survival number (e.g. 50% of 300 shrub seedlings survived first 3 years with at least 4 different species represented at the 10%+ level.) Measures: Grasses: cover point (best), quadrats (ok) or ocular estimate (least accurate).

MANAGEMENT RESPONSE TO LACK OF SUCCESS

For grasses, re-treat site and re-seed.

For shrubs, replant 2 or 3 new shrubs to every 1 dead.

CALIFORNIA ALPINE RESORT ENVIRONMENTAL COOPERATIVE
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Draft Technical Note 7
Monitoring

Description

Monitoring describes the observation or assessment of the outcome of an erosion control project. To evaluate whether the project is performing the way we intended and whether we have gotten adequate value, monitoring is essential. Types of monitoring include:

1) Baseline monitoring - pre-project assessment;

2) Implementation monitoring - assessment during or just after project completion to determine whether the project was constructed properly; and

3) Performance monitoring - assessment of the outcome of a project .

The types of monitoring described below, while not exhaustive, can be used in all three types of monitoring.

Appropriate Uses, Applications

Specific types of monitoring for erosion control projects are listed in the table below. Monitoring activity measures must directly link to project goals. For instance, measuring plant cover will not directly measure erosion reduction. Measuring soil density will not directly measure the aesthetic values of the project.

ALTERNATIVES

Table 7.1: Types of monitoring for erosion control projects

Alternative	Analysis
Photo point Monitoring	A simple, yet important component of any monitoring system. It is the least defensible type of monitoring however. Photo points are ideally mapped or linked to a geography point so that multiple photos can be taken over the seasons from the exact same location, or locations, so that visual observations can be made. Ideally, photos are most comparable if taken during the same time of day and similar lighting conditions. If project budgets are limited, photo monitoring should be minimized. If photo monitoring is done once yearly, it should be done on approximately the same day of the year or as closely as possible. Otherwise, for example, if one photo is taken in June when plants are green and vigorous and another is taken either in April before plants are growing or in October when plants have senesced, photos will be very misleading for project interpretation.
Cover Monitoring	There are several types of cover monitoring – see Hogan 2003. Generally, the more intensive the monitoring, the more reliable the information but the more time consuming. Cover monitoring ranges from visual or ocular estimates, which are very unreliable, to cover point monitoring done to a specific confidence level. Cover monitoring typically assessed plant cover by species or at least plant type, and ground cover, including mulch, rocks, woody debris, etc.
Soil nutrient Monitoring	Soil nutrient monitoring is used to assess the amount of nutrients in a project site so that adequate nutrients and organic matter can be added back into the soil. Nutrient monitoring can also be used post project to determine whether adequate nutrients have been added. It is advisable to use the same lab for all samples. A great deal of nutrient data has been collected for the Tahoe-Truckee area that may be applicable to other areas of the Sierra.
Soil Density Monitoring	Soil density monitoring is used as an index of infiltration of water into the soil. In other words, the less dense the soil, generally the more 'air' and pore space exists. The more pore space, the higher rate of infiltration. The amount of runoff is directly related to the amount of infiltration and thus to sediment yield. Soil density monitoring is done using a cone penetromer. It is extremely easy and rapid and gives a great deal of information about how well and how deeply tilling has occurred.
Erosion Monitoring	Erosion monitoring is usually done visually and should take place during or just after a runoff event such as a rainstorm or snow melt. Erosion monitoring can produce a great deal of information about the source of runoff, the amount of runoff and so on. This type of real-time erosion monitoring is essential to gaining a full understanding of the erosion process in ski resorts and elsewhere.

Known or measured outcomes

Suggested success criteria

Grasses (cover): increasing cover for first three seasons up to 40%, i.e.: year one - 10%; year two - 25%; year 3 - 40%.

Mulch (cover): year one - 98%; year two - 95%; year three - 90%.

Soil Nutrient Monitoring: soil organic matter within 20% of native or reference site for total nitrogen (TKN): at least 1500lbs/acre. This is an example only as each area needs to establish what the TKN is in adjacent robust native sites. See Claassen and Hogan, 2002 in Literature Review.

Soil Density: following treatment, penetration to 12 inches with no more that 250 psi (pounds per square inch) required.

Management response to lack of success

Grasses: re-treat and/or re-seed

Mulch: re-apply mulch

Nutrients: re-apply appropriate nutrient or soil amendment

Density: re-till to appropriate depth

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