part one
GUIDING PRINCIPLES

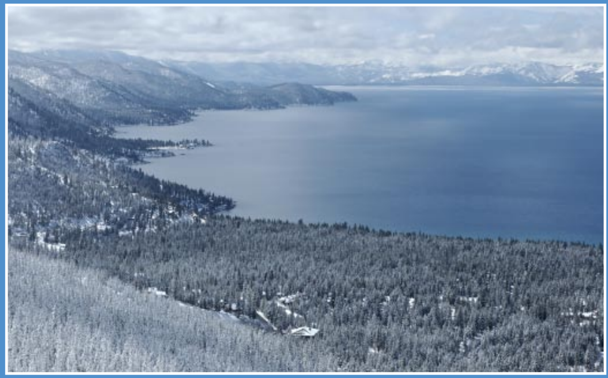


TABLE OF CONTENTS - Guiding Principles of Sediment Source Control

INTRODUCTION TO THE GUIDING PRINCIPLES

These Guiding Principles are intended to serve as the framework from which to plan, implement, assess, and improve erosion/sediment control and environmental restoration projects in ski resorts and beyond. They are not guidelines or standards per se, but are instead a set of principles that, taken together, represent an applied adaptive management process. They are intended to assist and GUIDE, rather than prescribe. Success is seldom attained by a first-time practitioner but instead tends to evolve over many years of experience, education, and information sharing. These guiding principles are not intended to be a substitute for actual field experience. Successful environmental projects usually require an adequate understanding of the setting within which one works. However, these guiding principles will help first-time as well as experienced project planners and implementers ask appropriate questions and design a project that has a higher probability of success. In environmental projects such as restoration and erosion control, there are no guarantees of success because of the extremely large number of variables that exist in the project. Some, such as extremes of weather and other natural phenomena, cannot be controlled or designed for. However, when all elements of the project are addressed as completely as possible, the project is much more likely to achieve the desired outcome.

The Guiding Principles are divided into three main sections: 1) Planning, 2) Implementation, and 3) Performance Monitoring and Follow up. These guiding principles describe an applied adaptive management approach to project planning, implementation, monitoring, and ongoing improvement that encourages a stepwise, direct approach. In this way, projects with complex variables become easier to understand and plan.

Guiding Principle

"A statement that articulates shared organizational values, underlies strategic vision and mission, and serves as a basis for integrated decision making. Principles constitute the rules, constraints, overriding criteria, and behaviors by which an organization abides in its daily activities in the long term."

http://www.ichnet.org/glossary.htm

NOTES

Each Guiding Principle follows a general format for consistency and accessibility and contains the following headings:

Goal

Describes the purpose of the Guiding Principle.

Description

Describes the Guiding Principle in greater detail.

Example

One or more examples of the Guiding Principle. In some cases the example also contains a solution or positive example of an application that supports the Guiding Principle. In other cases, the example describes a less than optimal situation that a particular Guiding Principle is meant to address. These examples were included in order to offer concrete examples of each principle.

Solution or Outcome

In cases where the example describes a sub-optimal situation, the solution section describes an ideal application of that Guiding Principle. Where the example describes an action, the outcome section describes the result of the action as it relates to the Guiding Principle.

Additional Suggestions

Describes any additional information or suggestions related to each Guiding Principle.

For references cited, please see the Reference List on page 224.

Toolkit

Most Guiding Principles also include a reference to the related Tools (Part Two) that describe specific treatment tools and strategies for implementing that Guiding Principle.

NOTES

FRAMING THE PRINCIPLES: The Adaptive Management Model

The Guiding Principles describe an operational adaptive management process. The concept of adaptive management has been applied for centuries under a number of different names. Physical engineers have used this approach since the first structure or bridge was constructed to continually learn from failures and successes to improve designs. In the realm of applied restoration sciences including erosion control, adaptive management has not been widely practiced and thus, unlike the engineering profession, we have not been able to clearly identify many of our failure modes. For instance, when we attempt to establish vegetation on a disturbed site and it does not establish as expected, we may not know why. Without this type of knowledge, we are likely to repeat past mistakes. The adaptive management process holds a great deal of potential for addressing many of the failure modes and thus can provide clear direction to improvement.

Adaptive management has a number of definitions. As used here, we assume the following: Adaptive management has a dual nature.

First, adaptive management is a philosophical approach toward resource management that acknowledges that we do not completely understand the system within which we are working. It acknowledges that we will proceed with a project or program using existing information while we gather the knowledge that we lack.

Second, adaptive management is a structured decision-making process that includes the following components, usually in stepwise and cyclical fashion:

- Articulate project goals, outcomes, and success criteria (future desired conditions)
- Collect existing knowledge and practices relative to achieving the goals
- Identify information gaps and related research needs
- Develop a strategy and apply knowledge and relevant practices toward achieving the clear project goals
- Develop a clearly defined and defensible monitoring program to determine whether the goals are being achieved
- Identify pre-defined potential management responses if the goals are not met
- Use monitoring data to determine whether success criteria have been met and whether a management response is necessary
- Reassess and improve practices and reconsider the goals or outcomes

While there are a number of manifestations of the adaptive management process, the CAREC partnership chose to use an adaptive management model as adapted from The Nature Conservancy and as outlined in Elzinga et al. (1998) and others (Ringold, Alegria, et al. 1996; Chiras 1990). Figure 1 represents the adaptive management model graphically. It is used throughout the document to illustrate where a particular step or practice falls within this model.

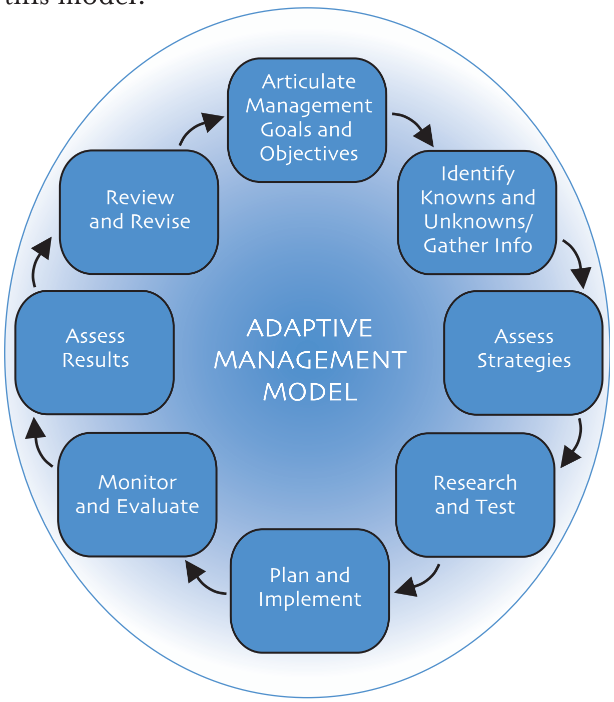


Figure 1: The Adaptive Management Model

SECTION 1: Planning

The Guiding Principles are divided into three sections. The first section deals with planning the project. Planning goes beyond just the project plans themselves and includes other less tangible issues such as clearly defining the project goals, the intended project outcome, including the appropriate individuals on a project team, and defining what success is expected to look like.

Guiding Principle 1: Identify the Need for Action and/or the Problem

Goal

To clearly understand both the need, or trigger, for taking action and the specific problem(s) being addressed.

Description

The steps are to 1) decide or understand why action is being taken and then 2) identify what the problem is or problems are. The need for action may often seem straightforward. Identifying the nature and cause of the problem is often more difficult. Action is sometimes taken without understanding the true nature or scale of the problem and thus may result in solutions that address the symptom, but do not directly resolve the source of the problem.

- Action may be triggered by identification of a water quality/erosion problem, such as rilling of a ski run or a mass failure (landslide). It may be triggered by new site development or disturbance such as the clearing of a new ski run or new road. It may also be triggered by regulatory agency request or any number of other circumstances.
- When the need for action is understood, it is critically important to understand the nature of the problem as completely as possible.
- It may take time to fully understand the nature of the problem. Time spent defining and understanding the problem(s) early in the planning process usually pays off because there is a much higher probability of focusing resources (people, equipment, and money) on the causes of the problem, rather than the symptoms. The contributing factors of the problem may become more apparent during the process of **site assessment** and **limiting factors assessment** (see Tool 3, Site Condition Assessment).

Example

A ski run is heavily rilled. Both resort management and the local USFS representative identify the rilling as a problem and source of sediment loading to a nearby creek. The area is re-seeded, mulched, and irrigated. Vegetation is established. However, after a summer thundershower, rilling is again noted.

Solution

Rilling was merely one manifestation of the real problem. A breached set of five water bars above the area of concern indicated a more complex problem. In this case, the lack of water infiltration in the soil across the entire ski run resulted in the surface runoff. The runoff was not stopped by either the vegetative cover or the water bars. This area will need soil physical treatment so that infiltration rates are increased and surface runoff is decreased (see Tool 8, Soil Physical Treatment). It may also need additional organic matter/soil amendments to maintain loose soil after soil physical treatment (see Tool 3, Site Condition Assessment).

Additional Suggestions

The erosion model below may provide a good starting point or checklist to help identify which elements of the erosion control process may be failing.

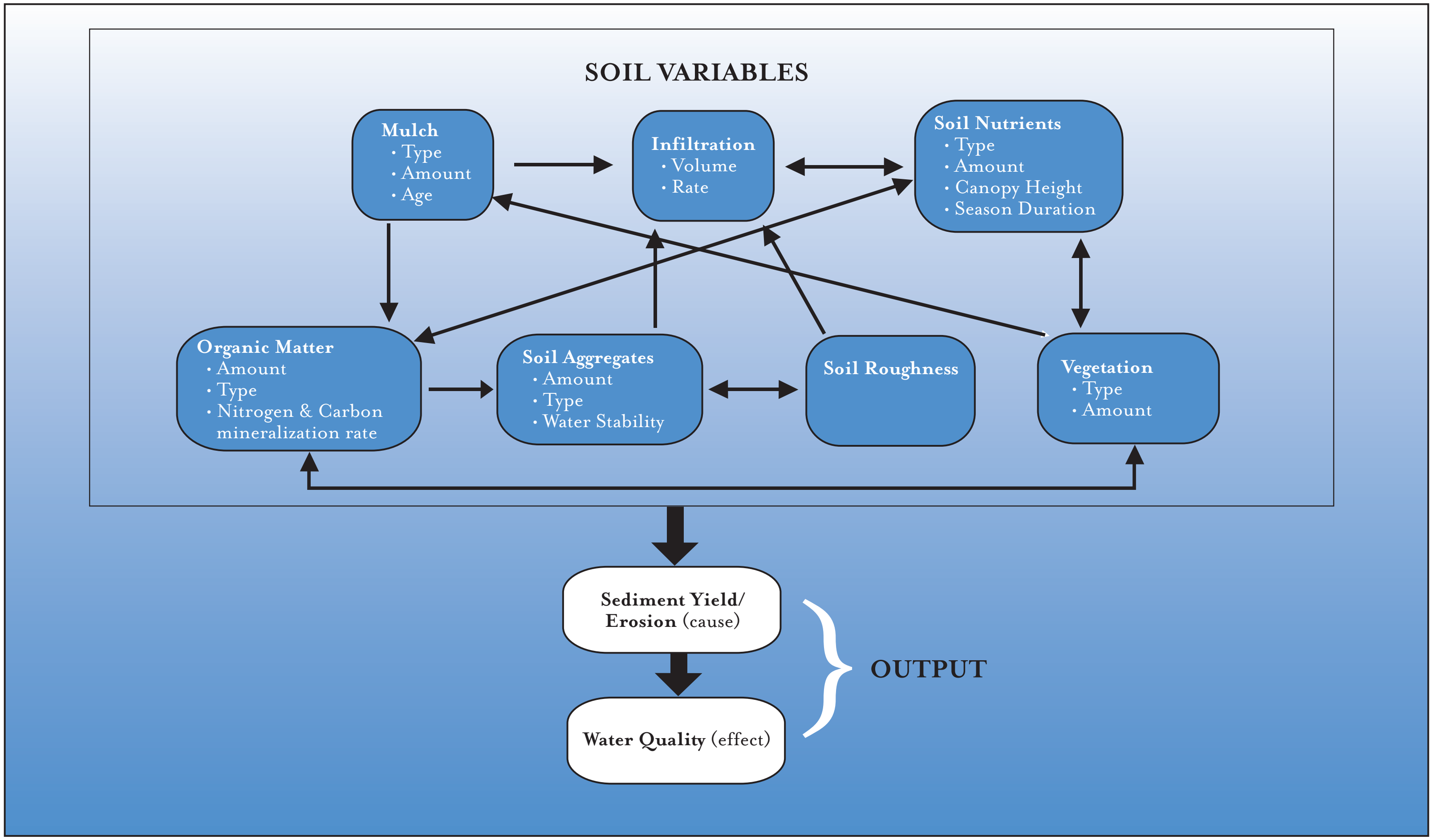


Figure 2: The diagram above represents a conceptual model of the variables that influence erosion processes. These variables are interconnected and must be considered as a system in order to fully understand an erosion problem and develop appropriate treatments.

Guiding Principle 2: State Project Goals and Objectives

Goal

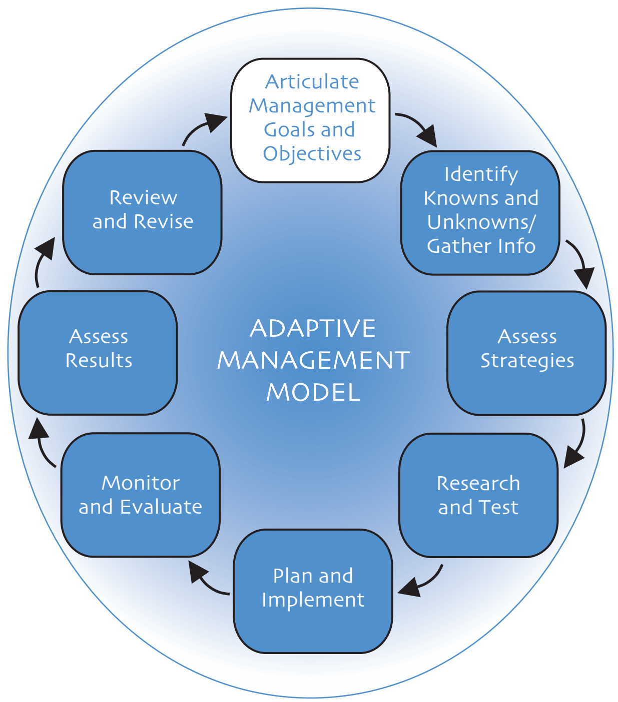
To define the desired project outcome(s).

Description

Developing and defining project goals and objectives allows the project planner(s) to define and perhaps iterate the intended outcomes. Further, where project participants differ in their point of view or individual mandates, the development of clearly articulated goals and objectives becomes the cornerstone for common understanding. The goals and objectives become the basis for "key agreements" which can be revisited during the project for clarity whenever necessary. Where regulatory staff and land managers interact on a project, the more clearly articulated the goals and objectives are, the easier it will be to determine whether those goals have been met. Thus, spending time early in the project to identify and agree on those goals and objectives can save a great deal of time, frustration, and money down the road.

Project goals and objectives should be reference points that define and guide the rest of the project. Ideally, these goals and objectives will be directly linked to **addressing the problem(s)/needs for action** that were identified in Guiding Principle 1. They should also be the foundation for monitoring and success criteria, which are described later in this document.

The words *goals* and *objectives* refer to similar concepts but differ in detail. As used here, goals are broad, general, and non-specific statements such as "controlling erosion on the ski run." Objectives are more specific and often measurable. Statements such as "reducing erosion on the ski run by 50% within two seasons through the use of mulch and revegetation treatment" would qualify as an objective.[1]



The terms *goals* and *objectives* can be confusing. For the purpose of this document, we use terminology that has been adapted from *Ecological Restoration and Watershed Stewardship Planning Terminology* (Stanley 2004).

Goals should be:

- Clearly stated and direct
- General and non-specific
- Inclusive (sediment control AND wildlife habitat maximization)
- Flexible enough to persist over time

Objectives should be:

- Specific
- Measurable
- Realistic and attainable (physically and economically)
- Directly related to the problem
- Time specific (state when and how long)

Success criteria are specific measurable elements directly tied to project goals and objectives (see GP 3).

Example

While goals are relatively non-specific, they can be problematic if not clearly related to the source of the problem. For instance, a goal such as "revegetate the ski run" is vague and may not be the appropriate solution for sediment source control in that area. The statement is based on the idea that vegetation will reduce or stop erosion. However, vegetation alone may not actually reduce erosion to the appropriate level. Poorly framed goals and objectives are difficult or impossible to measure, and thus do not contribute to improved sediment source control.

Solution

Identify Goals: To control erosion (on an eroding ski run) through full soil restoration treatment and native vegetation community establishment.

Identify Objectives: To establish an infiltration rate on the ski slope to levels similar to (within 10% of) a native forested area of similar slope and aspect in the vicinity, and to establish a native plant community with a cover level of 25% vegetative cover within three years.

Additional Suggestions

The process of defining goals and objectives can be simple and involve only a couple of individuals. With larger projects, it may involve a larger number of stakeholders. Generally, involving as many interested and/or affected parties as possible, and as early as possible in the planning process, minimizes unforeseen roadblocks later in the process. Further, when these goals and objectives are the result of regulatory requirements and/or public interest (and scrutiny), it is especially important to involve agency staff and/or members of the public as much as possible. That involvement may be to share the goals and objectives openly and does not necessarily mean that others will help develop them. However, in some cases, review and iteration of goals by a broader range of stakeholders can produce better, more inclusive and robust goals and objectives. Also, inclusion in the developmental stage often results in greater buy-in by all involved parties.

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Guiding Principle 3: Define Success

Goal

To define success in quantitative terms wherever possible so that the project outcome (at a specific point or points in time) can be clearly measured and understood.

Description

In order to measure the achievement of goals, goals must be translated into specific criteria. Success is defined by quantitative or at least clearly identifiable specific criteria. Success criteria must be achievable and practical. These criteria will generally include a number of elements, all of which taken together support the project goals and objectives. For instance, the percent plant and mulch cover, soil nutrient levels, soil density (cone penetrometer measurement), and visible soil movement are success criteria categories, all of which support the goal of sustainable site restoration. The most effective success criteria reflect the variety of elements needed to support the goals and reflect an integrated process.

Example

A project is being planned whose goals include both erosion control and aesthetic or visual impact improvements. Success criteria may include plant cover, mulch cover, adequate soil nutrients, no signs of visible erosion, low soil density, native flowering shrubs and forbs, and no bare areas.

Solution

Each of these elements will be assigned a quantifiable *"success" value* based on actual verified field plots and research. Based on the differing objectives, each project will probably have different site- and project-specific success criteria.

Additional Suggestions

Success criteria often represent indirect measurements of performance. For instance, soil nutrients do not measure plant growth but rather suggest the nutrients available for plant growth. Claassen and Hogan (2002) and others have studied and shown the relationship between soil nutrients and plant cover on disturbed sites. Cummings (2003) and others have suggested that success should be linked to functional elements such as hydrologic function (infiltration, water storage, etc.), nutrient cycling (soil nutrients, plant potential for cycling, etc.), and energy capture (plant and microbial biomass production and carbon processing, water storage in the soil), rather than just measuring or assessing the above-ground plant community (how the site looks). This change in emphasis may be much more effective in indicating long-term project success and can help in developing measurable success criteria. For instance, soil infiltration may be difficult to measure on each project, but a cone penetrometer can be used to determine soil density indirectly. Thus, if a lower amount of force is required to push the penetrometer into the soil, that soil is likely to be less dense and thus infiltrate more water than a compacted soil.

Toolkit

See Tool 4, Success Criteria, for additional information on developing success criteria.

Management Response *(See Guiding Principle 14)*

A pre-defined management response is an essential element of success criteria on projects that have a specific outcome or level of outcome in mind. Management response describes actions that are to be taken when success criteria are not met that will move the project toward achieving the success criteria. (See Table 4.2, page 79 for an example.) For instance, if vegetation success is defined as 20% total vegetative cover and that criterion is not met, management responses may include reassessing soil nutrients and soil density, and re-seeding the site. This process places the responsibility for action in the hands of the land manager. It defines when a management response is triggered and typically does not require regulatory agency oversight or input. A proactive and agreed-upon set of management responses prior to project initiation can maximize the efficiency of both agency and land managers, making interactions more straightforward and positive since follow-up is agreed upon in advance and not suddenly enforced through crisis regulations.

A Word About Time

The element of time is a critical consideration for developing effective success criteria. In order for a disturbed site to become self-sustaining, key functions must be restored. And function is a process over time rather than a specific point in time. However, in order to be effective, success criteria and project plans must define success at a particular point in time. The best success criteria will define more than one point in time and at each point, progress will be implied. For instance, if vegetation cover is declining over time, that may be an indicator that the site is not sustainable.

NOTES

Guiding Principle 4: Assemble the Project Team and Engage Project Partners

Goals

1) To identify and assemble appropriate planning, implementation, and monitoring personnel that will assure the best project outcome.

2) To include, to the extent appropriate, other interested/invested individuals.

Description

An effective plan and project requires appropriate team members. Project personnel should include those with an understanding of a) the nature of the problem, b) how to fix the problem, c) how to effectively carry out the plan in the field, and d) how to effectively monitor and assess the outcome of the project. Project team make-up and size vary greatly from project to project and from area to area. Simple projects can be managed with a small team or even by individuals, while larger, more complex projects may require a broad range of expertise. An effective team will include, at a minimum, a team leader/project coordinator and a person or persons with expertise directly relevant to the problem areas. A list of potential team members is included in the sidebar at the end of this Guiding Principle section. One common reason for project failure can be traced to planning and implementation by inexperienced individuals.

Another element of this Guiding Principle is the process of engaging other interested parties or partners in the project. This action will be relevant to each type of project. For instance, for a simple culvert replacement, there may not be any other interested parties. However, for larger, more complex and/or controversial projects such as clearing a new ski trail, there are likely to be individuals or groups that, by entitlement or inference, have a stake in the process. Increasingly, the adage is developing: "Ignore at your own peril." Interested parties may include those that have information on the project or project area that can help make the project more successful, or those that have a complaint or do not support the project. Early engagement of any of the aforementioned individuals or groups is likely to produce a better long-term outcome if they are engaged with a common, positive outcome in mind. Many "interested individuals" may surface at the eleventh hour in a project and demand any number of things. If that individual had been engaged earlier in the process, it may have been possible to clarify their perceptions and thus reduce their concerns. Last-minute resistance has stopped or seriously slowed down many projects.

The following sections describe the step-by-step process of developing a team and engaging other parties:

4.1 Select a Team Leader/ Project Coordinator

The most basic element of a team structure is the team leader, project coordinator, and/or contact person. In a simple project, this person may also have the expertise to plan and implement the project. In more complex projects, this person will be responsible for assembling and coordinating the team and should be the central contact point for both the team and the stakeholders.

4.2 Assemble a Team with Appropriate Expertise

Appropriate expertise is critical. A civil engineer will not usually have the expertise to address sediment source control issues and a botanist will not usually be able to design a retaining wall. The nature of the problem or project will determine the expertise needed.

4.3 Identify and Engage Interested Parties

Other individuals or groups outside of the project team may have valuable input or legitimate concerns about the project. If information is available from beyond the team, such as from a person who has historical information about the project site, those persons holding such knowledge should be contacted and engaged. Their information may add a great amount of value to the project in terms of reduced design costs or considerations of critical path elements that are not visible, such as old flow paths or abandoned roads.

Others may have legitimate concerns about the project. Where those concerns are discussed, either the project can respond to them if they were not originally considered or they can be discussed and often can be resolved through a better common understanding of the issue. Indeed, there are times when individuals or groups may not have legitimate concerns but may simply oppose the project for their own personal, but unstated, reasons. Often these individuals or groups will take a defensive or offensive stand. It still may be productive to engage them or at least listen to their concerns to the extent possible. If they are not willing to discuss and negotiate and their concerns do not seem legitimate or transparent, the only recourse may be to continue with the project without their input.

Example 1 – Small-Scale

A ski run has been identified as not meeting specific success criteria. It shows evidence of rilling, a large bare area, and two failed water bars. The mountain manager and the Regional Water Board representative discover these conditions during a routine walk-through. They agree that the mountain manager will provide the Regional Board with a plan to repair the problems and then, upon review, implement the plan.

The mountain manager contacts the erosion control manager on staff who has 15 years' practical experience and several courses in erosion, botany, soil processes, etc., and asks her to develop a plan. This plan is developed, submitted to the Regional Water Board, and approved. The erosion control manager then gives direction to the 3-person crew to carry out the plan as written.

Functionally, this project team is made up of five people: the project leader/coordinator (mountain manager), the planner/implementation director (erosion control manager) and the implementation team (3-person crew).

Example 2 – Large-Scale

A new ski run was defined in the Ski Area Master Plan of 1985. Funding has been acquired to construct this run, which skirts a wetland. Management has begun

NOTES

planning this year's construction schedule. In this case, the ski area planning director is responsible for project coordination. This project will be large and complex. The planning director engages planning, permitting, wetland identification and protection, civil engineering, botany, soil assessment, and revegetation/erosion control expertise. Planning will be challenging to coordinate. Further, a second level of the project team, who are kept in the loop through two-way communication, may include those in the community or interest group members who have general or specific concerns—such as intrusion into potential wetland habitat—that could present roadblocks later in the project if not addressed up front. The project coordinator will choose some or all of the expertise from the sidebar list, as appropriate.

Additional Suggestions

Assembling and coordinating an effective team is time-consuming and challenging. However, a great deal of project experience shows that when done properly, this process is likely to ultimately lead to a more effective and efficient project on the ground and can minimize challenges and/or roadblocks to project implementation. On the other hand, many projects have failed or had to be redesigned—at great expense—because the project proponent tried to save money by working beyond the true expertise of the team. During the planning process, additional opportunities may arise where information gaps can be identified within the team setting. That was the case for a Lake Tahoe west shore ski resort. Quantitative data relating to treatment and sediment reduction had been lacking. This resort, along with the project consultant, assembled a team that included the Regional Water Board and the local Resource Conservation District and applied for a grant to address this information gap. In 2008, the resort and partners received the grant and began doing work to address this gap. This is an example of a collaborative partnership that has brought significant additional funding to restoration efforts.

Potential Expertise / Team Members

PLANNING
Ski area managers
Project manager(s)/coordinator
Planners
Wetland specialist
Ski run construction specialist
Ski area implementation personnel
Monitoring specialists

TECHNICAL
Erosion control specialist
Revegetation specialist
Botanist
Geomorphologist
Watershed specialist, watershed hydrologist
Restoration specialist
Engineer

REGULATORY
USFS
EPA
Water Board staff
County staff (engineering and/or permitting)

COMMUNITY
Stakeholders
Environmental advocates

Note: A team may include some or all of the above listed members. Some 'members' may have a limited role. For instance, county staff may simply advise what permits will be needed and will then review the plans to make sure they adhere to county ordinances. Environmental advocates may offer input and review but may not actually develop plans unless they can offer positive input from a technical standpoint. Implementation personnel should review plans to ensure they are feasible. Engineers and erosion control specialists may be involved throughout the process. Recognize that individuals may have two or more areas of expertise; for instance erosion control, revegetation, and watershed hydrology.

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Guiding Principle 5: Assess Strategies for a Site-Specific Implementation Plan

Goal

To develop a sediment source control implementation plan that is based on specific site conditions and that targets clearly identified outcomes.

Introduction

This is perhaps the most complex Guiding Principle and actually includes a number of sub-principles. Care must be taken to understand and address each sub-principle.

Description

There are two main elements of this principle: 1) develop a plan that is based on and incorporates existing site conditions, including hydrology (water flow), soil, and vegetation, and 2) define a process for meeting the desired project goals, objectives, and success criteria. The following list details steps and considerations for developing that plan.

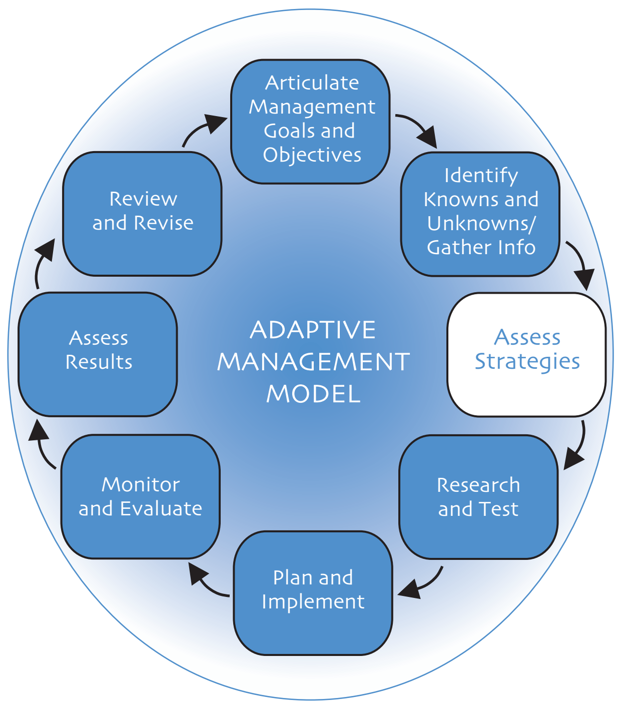
5.1 Assess Site Conditions

Document and understand existing site conditions in order to determine the nature of the problem, the causes of the problem, and the functional condition of the site (soil, hydrology, vegetation, and other elements).

A number of critical tools are described in the Toolkit (Part Two). The first step will be to understand and map water flow onto and from the site. This step is also used to determine site **Limiting Factors** (see Tool 3, Site Condition Assessment), which will be the foundation of developing a treatment plan, materials, and methods.

Example

Careful site assessment indicates that a rill or shallow gully has formed through the center of the project site and has, in fact, caused degradation and erosion throughout the site. By following the rill upslope, the team erosion control specialist discovered that an old road on the upper mountain has captured drainage and diverted it onto the project site, which is more than a quarter-mile away. In order for the project site to be protected and treated, the off-site road must be addressed or water will continue to run across the site, thus compromising the project. To address this relatively simple issue, a drainage and maintenance plan is developed.



5.2 Choose a Reference Site

Identify and assess a suitable reference site that represents a target condition, or reference, to aim for. Assessment measurements should include soil density, soil nutrients, vegetation type and amount, soil type, and a range of other elements. Choosing a suitable reference site serves two purposes: 1) a "good" or self-sustaining site typically defines success by the fact that it is sustainable, and 2) a reference site adds credibility to the goals and success criteria in that it can remove much of the subjectivity from the definition of success or desired future conditions.

Example

Soil nutrient analysis of a nearby reference site that supports adequate native vegetation suggests the appropriate level of nutrients needed in the treatment area. Vegetation analysis of a reference site suggests what vegetation community can actually be supported in this environment. By defining these two elements, success criteria are prepared and easily agreed upon by project partners. A reference site may be a native site or a previously treated site that is performing according to success criteria.

Note: it is important to understand the seral stage of a reference site and adapt the success criteria accordingly. For instance, a mature forest would seldom be chosen as a reference site since it would be impossible to achieve that condition in a meaningful time period. On the other hand, a mature shrub and grass community often is chosen as a reference site. However, success criteria in three years (or whatever time frame is chosen) may list a shrub density (rather than total cover), with the understanding that the treatment site is on the way toward becoming a mature shrub community.

5.3 Develop a Plan Based on the Two Previous Steps

The project plan is based on site conditions and information found in nearby reference sites. By comparing these two, a plan can be developed that is site-specific and achievable. "Stock" plans seldom address site-specific issues that must be understood and addressed in order to achieve success.

Example

A project site is analyzed for both soil density and soil nutrients. The project site has a soil density maximum of 500 psi (pounds per square inch) to a depth of 6 inches, at which point the penetrometer stops (reaches refusal). Total soil organic matter is 0.7% and total nitrogen (N) is 350 lbs/acre. The reference site, a previously revegetated site nearby with a high level of plant cover, has penetrometer readings of 225 psi to a depth of 16 inches. Soil nutrient analysis indicates 3.75% organic matter and 1,800 lbs/ac of total N. This baseline clearly indicates that the treatment site is deficient in soil nutrients and has a compacted soil, thus suggesting that soil tilling and organic matter amendments will be required as part of the treatment.

5.4 Maintain Natural Conditions to the Greatest Extent Possible

It is important to maintain natural hydrologic, nutrient cycling, topographic, and other physical conditions to the greatest extent possible on and around the project site.

Example

During construction, drainages will ideally be left unaltered. Topsoil will be left in place or salvaged and replaced. When one or more of these natural conditions is altered, the plan should re-create the natural conditions to the greatest extent possible. For example, if a drainage is intercepted and/or altered during the construction of a ski run, a new drainage should be constructed that mimics the pre-disturbance drainage as much as possible and/or routes the drainage through the project in a stable channel or conveyance. A road constructed across a hillside interrupts the dispersed surface runoff (site hydrology). The road should be "outsloped" and drainage should go across the road to encourage ongoing dispersion. Capturing the hillside runoff, by contrast, would concentrate water and build up erosive energy.

5.5 Consider Potential Alternative Treatments

More than one potential treatment should be considered. Treatment alternatives can be developed using the tools and techniques described in the Toolkit section of this document (Part Two) or using other appropriate, field-tested tools. Input and ideas should be provided by all members of the team. Time, intensity of the problem, and available resources will define which tools will be most appropriate.

Example 1

A steep slope is eroding and depositing sediment near a stream. Alternative treatments may include silt fencing, straw bales, full soil-restoration treatment, or mulching. The project team reviews the alternatives from different perspectives. Given the proximity to the stream and the temporary duration of some of the potential alternatives, the full soil-restoration treatment is likely to be the most effective though initially the most expensive of the alternatives. However, when long-term maintenance/replacement costs are considered, this most-effective alternative could prove to be the *least* expensive option available.

Example 2

A nearly flat area erodes during high intensity rainfall events. This area is 500 yards from the nearest creek, and runoff must travel through a great deal of duff and vegetation to reach the creek bank. Alternatives include full soil-restoration treatment, mulching, tilling of wood chips, straw bale barriers, or a silt fence. Given the distance to water, the flatness of the slope, the easy availability of wood chips, and the fact that budget constraints exist (it's a ski area), the project manager chooses to till wood chips into the soil to increase infiltration and mulch the soil surface with no further treatment. If this treatment meets the success criteria (no measurable erosion off site and high rates of infiltration), this would be an effective and cost-saving alternative, though it may need re-treatment in the future as the mulch breaks down.

5.6 Incorporate Tests Where Information Gaps Exist

There are more questions than answers relative to sediment source and erosion control. When choosing treatments, planners will encounter information gaps with regard to materials, treatments, time frames, etc. Wherever possible, treatments should be overlaid with tests to help answer those questions and fill information gaps. In this way, each project adds to our collective knowledge base and potentially enhances future project outcomes and costs.

Example

A recent erosion control conference presentation showed that a specific fabric significantly reduced erosion during year one of a large project in South Carolina. A steep road cut near Mogul Lift has been eroding and management has decided to address the problem. The budget is too small to apply fabric to the entire area. Management is also not sure how the fabric will respond to snow over the long term and wants to test it in local conditions. They are able to afford 500 ft^2 of the fabric, which is applied to one portion of the project. In the following three seasons (the time portion of the success criteria) the entire site is monitored, comparing the fabric area to the standard treatment, looking for signs of erosion and measuring plant growth for differences. This test was relatively inexpensive and provided valuable information regarding whether the fabric contributed to achieving the success criteria and its general usefulness for controlling erosion in high alpine areas.

5.7 Choose Appropriate Treatments

The treatment alternatives that are chosen should be adequate to meet project goals and objectives, should be based on site assessment so that they will fit the site, should be field tested if possible, and should be aligned within project budget parameters.

Example

In the first two of the previous three examples, if a silt fence had been chosen, it is unlikely that effective project outcome would be achieved. Silt fences are temporary structures, tend to be compromised by snow, and fail to address root problems. CAREC is committed to avoid these "do something, even if it doesn't work" treatments by rigorously testing alternative approaches. Therefore, treatments that improve soil conditions such as addition of organic amendments and soil loosening, combined with a locally-derived or adapted seed mix and a robust cover of mulch, will support increasing function over time and, if the right type and amount of organic amendment is used, will support project sustainability.

5.8 Identify and Address Potential Threats to Project Success

Impacts on treated sites such as post-project vehicle or foot traffic, skier or Sno-Cat impacts in areas with low snow, lift tower access, recreational trails, or potential ATV traffic need to be considered and addressed. If these impacts cannot be eliminated, protections must be put into place if overall project goals are to be met.

Example

A ski run is smoothly graded. Topsoil is replaced and the site is tilled, seeded, and mulched. After a fall rain, grass begins to germinate. While preparing the snowmaking system, mountain staff decides to drive quads straight up the slope in order to access snowmaking hydrants at the top of the run (in this case, there was a longer access road available to the top of the run). Other staff, seeing the tracks, also begin to use the shortcut. During a late season rainstorm that produces 2 inches of rain in less than an hour, the tracks from the quad become water flow paths and transport sediment to a nearby creek, resulting in a violation from the Regional Water Board. Before the area can be repaired, snow falls. During spring runoff, those tracks continue to transport sediment into the creek, resulting in additional violations. (In California, the Regional Water Board can fine a discharger up to $10/gallon for sediment-laden water delivered to a creek.)

Toolkit

See Tool 3, Site Condition Assessment, for more information.

Simple Fixes

Beware of fixes that seem too simple or like the proverbial "silver bullet." We would all like to find these types of solutions, but they have typically not been shown to be effective in the long term because ecosystems are complex and always changing. However, learning can be one of the most rewarding aspects of a project and can lead to great cost savings and/or more successful projects in the future.

SECTION 2: Implementation

This section describes processes that will assure maximum success when applying sediment control treatments in the field. The Guiding Principles in this section assume that a carefully constructed plan has already been developed.

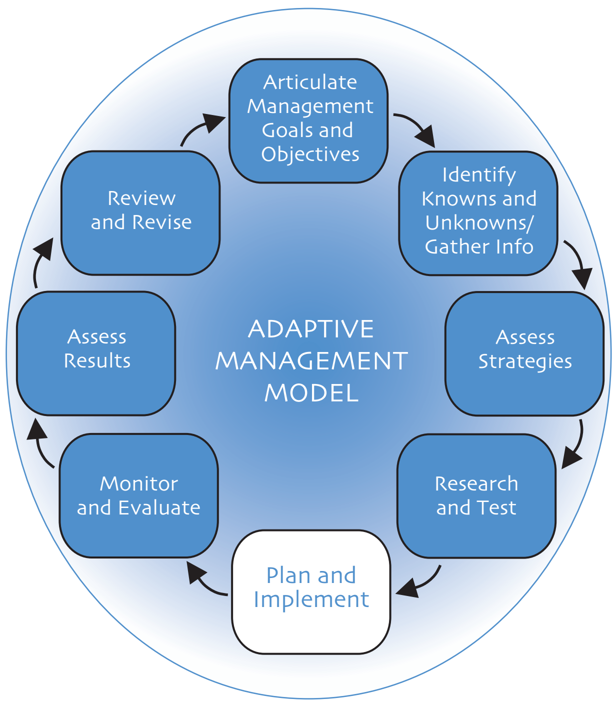
Guiding Principle 6: Train Staff and Associated Personnel

Goal

To increase the level of awareness and understanding of the sediment source control program and build competence in all staff involved in project treatment activities as well as those who are not. This Guiding Principle is for internal resort protocols and practices.

Description

Training is critical to develop competence in and raise awareness of sediment source control, as well as to ensure that no post-treatment disturbances disrupt the project. Implementation staff must be fully versed in project goals, implementation strategies, materials, and techniques. Clear articulation of these elements can make the difference between success due to correct installation and failure due to incomplete or incorrect installation. General resort personnel must understand travel restrictions and ways to avoid inadvertently affecting treated areas. Strategies need to be developed and shared to minimize impacts to treatment areas, such as by mountain bikes, ATVs, etc. (see Tool 15, Protecting Treatment Areas). With full staff support and understanding, treatment areas will be better managed. Further, when personnel understand erosion processes and goals, they can help spot, and possibly repair, small problems such as water bar breaks or clogged culverts. This process, if done effectively, also develops ownership of the outcome of the project or process.



Example 1

A small ski area maintenance crew is spreading compost on the Downhill Run so that it can be tilled in and revegetated. They haul the compost to the run and push it over the side, covering the run as told to do. Unfortunately, the compost is 1 inch deep at the top of the run and 9 inches deep farther down. Remedying this mistake costs an additional four hours for three people. If the mistake were not remedied, the uphill portion of the project would not produce adequate vegetation and thus not meet success criteria, and the downhill portion of the project would pose a water quality threat due to excess compost being washed from the project site into a nearby creek.

Solution 1

A 15-minute training session that explains the soil restoration process and why compost needs to be spread evenly for tilling, and then **demonstrates** that process, would help ensure that the crew distributes the compost effectively and efficiently the first time.

Example 2

The Lower Concourse area near lift 500 has just been recontoured and restored along an old, seldom-used lift access road. To access a new area designed for summer concert activities, Joe Liftoma, a long-time lift mechanic, drives straight across the treated area in the approximate location of the old road. This ruins the treatment and requires soil tilling to get rid of the 4-wheel-drive ruts, plus the added expense and time needed to recontour and replant.

Solution 2

A memo sent to all personnel, communication with department heads, and a directive from the Operations Manager indicates that all treatment areas are to be protected and are strictly off limits to foot, vehicle, and equipment traffic. The memo details the accepted driving routes. An on-site meeting with all affected staff reinforces this directive. A system of personal accountability will help achieve these goals.

Additional Suggestions

This proactive step, while requiring more up-front time, is essential for managing treatment sites. A structured communication process from sediment source control personnel to the rest of the staff can help to meet goals and gain widespread support for the program when staff understand the purpose and strategies being implemented on the treatment sites. This communication may need to be repeated annually, or even seasonally, as personnel change.

Toolkit

See Tool 15, Protecting Treatment Areas, for additional information.

NOTES

Guiding Principle 7: Oversee and Document Activities

Goals

1) To oversee implementation of erosion control activities in order to ensure proper implementation of planned treatments.

2) To document implementation of treatments in the form of as-builts, reports, and/or other implementation monitoring documentation. Precise documentation provides information that allows for useful future interpretation of project results, supports ongoing monitoring efforts, and may help satisfy regulatory requirements.

3) For contracted projects, to provide assurance that the contractor is doing the best job possible, thus providing high value to the owner.

Description

Implementation oversight, sometimes called implementation monitoring, assures that treatments are implemented as defined in project plans and specifications. This step is also used to make adjustments to specifications in the field where plans are not feasible as written or where some other method may simply work better.

During implementation oversight, notes, drawings, and photographs that explain what was done, how it was done and when, who was involved, any changes to the original plans, and ideas for alterations or method improvement should be documented. The erosion control manager must ensure that implementation is tracked and then check for accuracy and a consistent tracking format across all projects. Communication of these elements in a timely manner to the appropriate team members is critical. Thus, an effective communication and accountability system needs to be in place in order to ensure the success of this process.

Example - Oversight

A manager instructs his crew to seed the Uphill Down ski run after a snowmaking line is installed. The manager is not able to supervise the project, which requires coordination between the snowmaking installers and the revegetation crew. The snowmaking line is installed and backfilled and the revegetation crew hydroseeds the area. The following day, planned snowmaking equipment movement tears up the hydroseeded area.

Solution - Oversight

Effective coordination or direct oversight of this project would have allowed the revegetation crew to know that the snowmaking crew would need to re-access the area within the week. This would have resulted in only part of the area being revegetated initially. The crew was unaware that lateral lines were being installed, requiring additional entry. Better coordination would have saved five hours of labor and $700 worth of seed and fertilizer.

Example - Documentation

Erosion control treatment is installed along the length of a full ski run, with two cost-effectiveness test areas along one side, where compost is being compared to aged wood chips. The project manager does not record or photograph the process, nor indicate the location of the test plots on a map. She is sure she will remember this simple layout and will record it before winter begins. However, she forgets to record the layout because of the onset of an early winter. During the winter, she takes a beach break and disappears over the Bermuda Triangle, never to return to work. The following season, one plot has much higher plant growth than the other, but nobody knows which treatment was installed where or how much compost or wood chips were applied.

Solution - Documentation

The project manager used the as-built template (see Tool 14, Documenting Treatments) and provided additional information about the treatment. She also put stake chasers at each corner and marked the corners with small rock cairns. She then mapped the site using GPS and created a site map with the coordinates. The following season, her replacement knew exactly what was done, where it was done, how deep the soil was tilled, the exact seed mix, and who worked on the project in case of questions. He also had photos of the treatment process so he could better understand how the treatments were implemented.

Additional Suggestions

Project oversight can make the difference between success and failure. While plans may be carefully prepared, there is no guarantee that they will be properly implemented. There are many incentives to install treatments at a substandard level, including cost, time, and personnel. Adequate project oversight by knowledgeable, empowered individuals can prevent substandard treatments and will often pay for itself in the end. Project documentation and tracking can make the difference between knowing why a project treatment worked and having no idea why it succeeded or failed. Both elements take extra time initially but significantly reduce wasted resources and frustration, and can lead to more cost-effective projects in the future. In addition, cooperative and proactive oversight can often lead to more cost-effective and innovative techniques being developed by the contractor and incorporated into future project plans.

Toolkit

See Tool 14, Documenting Treatments, for additional information and an example of an as-built report.

NOTES

Guiding Principle 8: Protect or Optimize Hydrologic Function

Goal

To maintain or create site conditions where hydrologic function, especially surface hydrology, is accommodated and does not degrade the site or the watershed.

Description

Surface hydrology (flow patterns) typically has a major influence on watersheds and on specific projects. When disturbance occurs, some of these flow patterns can be disrupted. Site and watershed hydrology, especially surface flow patterns, must be well understood and accommodated in the site assessment and planning process. Planning for and accommodating natural surface flow is critical whenever new developments disturb the soil. The most effective approach is to leave existing flow patterns undisturbed and design around them. Where that is not possible, a high level of practical planning is needed to address and accommodate existing and potential water flows.

Example 1

A ski run was built that intersected an existing drainage. However, the project engineers who designed the project had little understanding of intermittent surface hydrology. The old flow patterns were not accommodated in the design, and in three subsequent runoff events, major erosion damaged the ski run. Each time this occurred, a great deal of time and effort was required to fill in the gullies and in two cases, to fix the snowmaking lines that were exposed.

Solution 1

Finally, the mountain manager and an erosion/hydrology specialist collaborated and decided to identify and rock-armor and seed the primary flow paths. This resulted in a stable, vegetated site that is capable of carrying seasonal and pulse runoff without eroding.

Example 2

A new ski run was cut down a steep north-facing slope that holds snow late into the spring. This slope was logged more than 40 years ago, and remnants of four legacy logging roads that transected the slope were still present. The ski run was cut and successfully revegetated. Five years later, large, 3-foot-deep headcuts and trenches could be seen from across the valley during the summer. Large amounts of sediment from those trenches (gullies) were deposited into the nearby creek, reducing summer flows and essentially ruining the little remaining fish habitat.

Solution 2

Two elements of this situation contributed to the problem. The most obvious is the capture of flows from the four roads by the ski run. This contributed to high volumes of concentrated surface flows. In this solution, the legacy roads were eliminated (full re-contour restoration), surfaces restored, and the road capture of runoff water eliminated. A related and more subtle issue is that the construction of ski runs tends to result in a great deal of compaction, particularly in high-clay soils. Compaction results in very low infiltration rates and greatly increases sheet flow runoff, which also contributes to sediment movement throughout the entire ski run. This type of erosion is difficult or impossible to see until rills and gullies begin to form. The solution was to add organic matter to the soil surface and till the run in strips across the run face to maximize infiltration. This process effectively reduced surface flow by 600%, thus reducing, and in many cases eliminating, erosion.

Additional Suggestions

Designing for effective hydrologic function related to roads, ski runs, and other disturbance areas needs a great deal of further investigation. Standard Best Management Practices (BMPs) do not tend to deal with this issue in a systemic manner. In developing the project team, an experienced erosion specialist with a background in hydrology should be consulted. Some ski resorts may have experienced staff who, through years of experience and observation, may already have these skills.

Toolkit

For more specific information on maintaining and restoring hydrologic function, see:

- Tool 2, Watershed Flow Assessment
- Tool 3, Site Condition Assessment
- Tool 18, Accommodating Water Flow

NOTES

Guiding Principle 9: Protect or Optimize Soil Function

Goal

To create soil physical and biological conditions that optimize water infiltration and have robust and stable nutrient cycling and sustainable plant and soil microbial communities.

Description

Soil is the foundation of terrestrial ecosystems. Soil functions include nutrient cycling, water storage, water infiltration, plant support, microbial activity, and erosion resistance. Soil physical and biological conditions are the primary determinates of how erosion-resistant a site is. Maximizing soil function on disturbed sites is done through:

- Soil assessment to determine soil density, soil nutrient content, and nutrient cycling potential;
- Soil amendment (organic matter) addition where suggested by soil samples; and
- Soil loosening where density is high and/or where organic matter is to be incorporated into the soil profile.

Where soil function is compromised, project success is highly unlikely. Maximizing soil function may be the most difficult to achieve by using intuition since soil function potential can be largely invisible and tends to require interpretation by an experienced soil specialist.

Example 1 – Large-Scale

Two adjacent ski runs were constructed. The planning team just attended a seminar where it was suggested that tilling and organic matter amendments are important elements of disturbed site restoration. On one run, a standard smooth grading technique was used, employing a bulldozer to smooth the entire run, burying rocks, stumps, and topsoil. Following grading, 2 inches of compost, native grass seed, and pine needle mulch were applied, with the compost tilled in. The other run was constructed using a non-intrusive "pluck and chuck" technique whereby trees were cut (over the snow) and large rocks were removed by an excavator, which made one pass down the run.

Outcome 1

The first, smooth-graded run was extremely expensive to construct but due to requirements by the US Forest Service, robust growth was required, and thus soil amendments were used to replace the buried topsoil. The year following treatment, vegetation growth was moderate. Two inches of compost was not enough organic matter to replace the buried topsoil. However, no erosion was observed, despite minimal plant growth. The second, non-graded run required no further treatment, and since all topsoil was left in place, there was no evidence of erosion. That run required more snow to open than the first run but retained a much more natural aesthetic and offered a more pleasing view from the nearby popular summer hiking trails.

Example 2 – Large-Scale

A hotel was built as part of a ski resort expansion. During the construction of the new main feeder road into the resort, a soil and erosion specialist suggested that all topsoil be removed prior to construction and re-spread after cut and fill slope construction was complete. This was done, and additionally, all of the small trees and root balls were put through a tub grinder and the wood shreds were stockpiled on site. After topsoil placement and tilling, seed was applied and the wood shreds from the tub-ound trees were used as a surface mulch. Since the slopes were relatively steep, water truck irrigation was used in order to germinate the grasses so that their roots could develop the required soil strength. Since the soil was well loosened, water from the water trucks, when applied properly, infiltrated into the soil. This project approach saved the developer a great deal of money since no compost or other soil amendment was used and no permanent irrigation system was installed. Three years later, a robust native grass and shrub plant community was well established and no additional irrigation was required.

Outcome 2

This project was considered successful when measured against the project success criteria. Self-sustaining native vegetation and no visible erosion were the primary success criteria for this project.

Lessons Learned:

1) Early in this project cycle, loose topsoil was placed on a relatively smooth road cut surface. During the first winter after treatment of some of the slopes, more than 27 inches of rain fell in one month, saturating the soils and causing some mass failures, largely due to lack of root establishment. In the second season, water truck irrigation was used, as described above. The project planners learned that water truck irrigation could be quite effective if done properly and on an appropriate schedule since loosened soil allowed water to infiltrate rather than run off, as is usually the case with water truck irrigation.

2) The second lesson learned was that smooth surfaces beneath topsoil can lead to mass failures in very wet conditions. Therefore, the contractor was directed in the future to "scallop" the subsurface region in order to help anchor the applied topsoil and increase the subsurface coefficient of roughness (see Tool 8, Soil Physical Treatment).

Example 3 – Small-Scale

A highway was constructed in Central Oregon. Road cuts were comprised of extremely fine, powdery volcanic soil, very much like soils in many Sierra ski resorts. Soil specialists were called in to assess the potential for that site to erode. It was determined that the soils, after being cut into, were very low in organic matter and were unlikely to support plant growth or to establish the microbial community required to help aggregate the soil. In a small, 40-foot by 70-foot section, compost was applied and tilled into the soil, in order to ascertain whether adding some amount of organic matter would support establishment of vegetation and would help control erosion.

NOTES

Outcome 3

Four years following this small test application, a robust, non-irrigated, self-sustaining native grass community had been established, in contrast to the sparse vegetation on the adjacent, non-amended portion of the site. While this application of organic matter was not used on the entire site, and is unlikely to be used on a large scale due to the relatively high cost of compost, the small comparison site will allow planners to understand that this type of application can help them achieve the type of vegetation community desired and to consider the cost-benefit of a wider range of treatment alternatives.

Additional Suggestions

Our understanding of soil processes and soil amendments for steep wildland areas is still in its infancy. Information gaps related to soil function present a range of opportunities for testing.

Toolkit

The Toolkit section (Part Two) of this document describes several tools and techniques for maximizing soil function, including:

- Tool 3, Site Condition Assessment
- Tool 7, Topsoil Salvage and Reuse
- Tool 8, Soil Physical Treatment
- Tool 9, Soil Amendments
- Tool 16, Monitoring

Saving and Reusing Topsoil

One of the most effective methods to maximize soil function is to save and reuse topsoil wherever possible on a new project. Topsoil contains stable organic matter, millions of microbes, and thousands of seeds in every cubic foot. Saving topsoil or not disturbing it in the first place are valuable tactics that cannot be easily replaced by subsequent treatment. Compost and other organic amendments are poor substitutes for topsoil. Every effort should be made to save topsoil.

Guiding Principle 10: Protect or Optimize Mulch and Surface Protection

Goals

1) To provide surface cover and protection as the first line of defense against erosive forces.

2) To provide long-term nutrient input to the treatment area (not applicable for all projects).

Description

Surface cover, or mulch, is a critical and potentially the most cost-effective sediment source control treatment. Mulches vary widely in both form and function and include wood fiber mulch, straw, wood chips/tub grindings, pine needles, gravel, erosion control blankets, and others. Mulch should be applied heavily enough to control surface erosion, and long-lasting materials should be used for permanent applications. Temporary surface covers, such as erosion mats and blankets, can also be used, but these materials do not typically provide adequate long-term (>2 years) protection.

Mulches are known to provide some or all of the following benefits:

- Interception of raindrop energy
- Reduction of surface water flow velocities, reducing erosive (shear) forces, and increasing runoff residence time and infiltration
- Filtration of sediment entrained in surface water flows
- Long-term, slow-release nutrient source
- Infiltration by increasing soil biologic activity/soil aggregation
- Attenuation of soil temperatures
- Reduction of evaporation from soil
- Weed suppression
- Aesthetic benefits

Mulches vary widely in appearance, durability, and cost. Wood chips or tub grindings are a popular choice in the Sierra Nevada. Pine needles have recently gained wide acceptance as an effective mulch that results in a natural-looking surface after application. Erosion control blankets are often used on very steep slopes. However, a great deal of recent monitoring work in the Sierra Nevada has shown that many erosion control blanket applications allow erosion to occur beneath the blanket without being observed. Blanket-type methods of surface protection vary widely in effectiveness and longevity.

Example 1

A planner identified bonded fiber matrix (BFM) as the mulch of choice on a new ski area road cut. This was intended to be a permanent installation. A wood fiber BFM was mixed with seed and fertilizer, then applied (with no other soil treatment). After two seasons, very little plant growth had occurred and the road cut was becoming heavily rilled due to surface runoff.

Solution 1

Mulch selection and application should be linked to project goals and the service life of the mulch. If a short-term, temporary mulch such as bonded fiber matrix is used (1-2 year service life), a follow-up application is necessary. Unfortunately, in this case, short-term cost savings overrode long-term project goals, and therefore the site was not tilled, amended, seeded, or mulched properly. In retrospect, some or all of those treatments should have been applied. In a nearby project with identical conditions, the fully treated site has maintained a high level of plant cover and erosion resistance over many years. Conversely, the site treated with BFM was inspected by the county inspector and since it was delivering a large amount of sediment to a nearby creek, was required to be re-treated, resulting in additional, unplanned costs.

A note on BFM: While this mulch choice may not be cost-effective, it does contain synthetic materials. There is mounting evidence that polymers have a negative impact on ecosystems. Use of natural materials is preferable.

Example 2 – Large-Scale

During an erosion assessment, a ski resort operations manager discovered that a long, narrow ski run had developed a number of rills and a moderate-sized gully, all of which led to a nearby creek. Access to the run was difficult and his budget was slim, but he recognized that something had to be done to address the issue. Coincidentally, this resort had undertaken a fuels reduction program, which produced a large volume of wood chips that were being hauled off site. He decided to use some of the excess wood chips to mulch the run. However, he was still worried about the potentially high cost of spreading the wood chips on the run, which would likely have to be done by hand, given the steep slope and difficult access.

Solution 2

The snowmaking supervisor, who also worked on the summer maintenance crew, noted that they would be making snow in a few weeks and suggested that it would likely be more efficient to spread the wood chips over the snow using the food service Sno-Cat, which was equipped with a large bed. One month later, wood chips were spread over the entire run in two days using the blade on the Sno-Cat to spread the wood chips down the slope. The operations manager estimated that spreading wood chips over the snow saved $3,000 in labor costs for this run compared to hand spreading. The following summer, the crew returned with an excavator to finish the restoration treatment. They used the teeth on the bucket to loosen the dense soil and poke in the wood chips, then spread seed and raked out the remaining wood chips to cover the seed. The operations manager has continued to use wood chips both as a mulch and a soil amendment to treat erosion problem areas that are near fuels reduction projects. This approach has improved the effectiveness of the resort's erosion control projects and saved money by reducing the need to import soil amendments and haul away wood chips.

Example 3 – Large-Scale

A 20-acre, smooth-graded ski run was severely eroding due to surface runoff. The resort operator priced the application of surface mulch to the entire ski run and found that the cost was prohibitive.

Solution 3

Working with the local Water Quality Control Board and an innovative local contractor, a plan was devised to create 6-inch-deep, 4-foot-wide mulch strips using tub grindings across the run. These mulch strips intercepted and filtered sediment from surface flows. By linking this treatment to the project goal of reducing erosion, and by monitoring the outcome, it was shown that this application was nearly as effective at reducing erosion as mulching the entire ski run but was implemented at a fraction (about 35%) of the originally projected cost.

Additional Suggestions

Mulch use has changed a great deal in the past ten years, with more emphasis being placed on long-lasting, durable mulches. During certain times of the year, a large portion of the garbage/waste stream in a ski community consists of materials that can be used as mulch (such as pine needles). As forest fuels reduction work continues, wood chips and other long-lasting, inexpensive mulches may become more readily available.

Toolkit

See Tool 12, Mulches, for additional information and case studies.

Guiding Principle 11: Protect or Optimize Appropriate Vegetation Community

Goal

To apply the appropriate plant materials to achieve project goals.

Description

Vegetation is an extremely important component of any integrated treatment approach to controlling erosion on disturbed sites. The appropriate type, amount, growth form, and condition of vegetation used will affect both the soil succession and the overall project outcome. Vegetation choice should be linked to soil treatment type, site condition, project goals, and desired outcomes.

Vegetation considerations are complex, and knowledge of native plant species and communities is somewhat limited. Considerations for choosing plant material will include some or all of the following:

- Is the plant species easy to establish?
- Does the chosen species germinate easily and grow quickly from seed?
- Is the plant species appropriate for the site?
- If planted from seedlings, what is the expected (and observed) survival rate?
- Does the plant mixture require additional irrigation, and if so, has that irrigation been planned for?
- Does the species regenerate itself?
- Is it an *indigenous* native species?
- Is there risk of a non-native species becoming invasive?
- Is the plant material of choice locally available and in sufficient quantities?
- Does the chosen plant material fit budget realities?
- Can the species survive in a ski run situation (i.e. regular grooming), especially with low snowpack?
- Does the species fit with the desired aesthetic?
- Does the species stabilize the soil?

Example

A steep-cut slope consisted of high-density soil. This site was revegetated with expensive native shrub plantings that were placed in standard planting holes. Planting was difficult and required additional irrigation that actually created erosion during application. Within two months of installation, a late summer rainstorm delivered 1.25 inches of precipitation in less than 45 minutes. Following the thundershower, rills covered the entire slope and approximately 1/3 of the plantings had washed away.

Solution

Habitat or aesthetic goals were confused with soil stabilization goals. In this case, a full mixing of soil and organic matter, combined with the seeding of a grass mixture and low-flow irrigation during the initial establishment period, would have provided the soil with surface protection and soil strength through root structure. Native seedlings are often less effective than grasses for soil stabilization in the first few months after treatment and have shown a propensity for increasing erosion in the short term. A good seeding of grasses and a robust mulch cover (assuming adequate infiltration) would have provided early protection for this area. In subsequent years, seedlings could have been planted to provide a long-term plant community for slope stabilization and deeper root penetration.

Additional Suggestions

Little is known about many native species in terms of direct seeding, transplant viability, propagation, etc. (see **Native Plants Journal** http://nativeplants.for.uidaho.edu/), though this type of research is already under way throughout the West. Planting and tracking survival rates of different native species on each project can provide valuable information to inform future treatments and improve understanding of different plant materials.

Toolkit

See Tool 11, Vegetative Treatments, for additional information on application and effectiveness of different plant materials.

Guiding Principle 12:
Protect Project Area from Further Disturbance

Goal

To reduce or eliminate post-project disturbance in order to maximize treatment benefits.

Description

Once an area has been treated, additional disturbance is likely to re-compact or otherwise disturb the soil, reduce infiltration, and destroy vegetation. Protection against post-treatment disturbance is critically important for project success. In many cases, protection against post-treatment disturbance should be built into the project plan. For example, in some areas where foot traffic is known to occur, an erosion-resistant trail should be designed into the project to keep people off the treatment area. Or, if a quad road is needed, the project planner can incorporate it into the design to provide site access and still reduce erosion.

Example 1

Construction of Bubba's Run had just been completed and subsequently treated. Vegetation was just beginning to sprout when Bubba himself, a much-loved and now retired staff member, decided to take a quad trip to see what his run looked like in the summer. He took the summer road to the top of the run and, in a fit of pride and exuberance, headed straight down the run on his quad. The irrigation technician (also a snowmaker) had just completed watering the run, so Bubba's trip down was a bit slippery and required some skidding. The next spring, two large tire tracks/rills were visible from the top to the bottom of the new run. During that summer, a large thundershower turned those rills into gullies and transported sediment into a nearby creek.

Solution 1

Guiding Principle 6 discusses the importance of staff training. However, not all staff, and certainly not the general public, know to avoid treated areas. In dealing with both staff and visitors, physical blockades, signage, and warnings help enforce the message. Blocking previous access points with boulders, logs, ribbon, and possibly signs would have eliminated a large and growing sediment delivery problem on Bubba's Run. Clearly defining access trails and roads can contain traffic and prevent treatment areas from being re-disturbed.

Example 2

A large disturbed area has been treated/revegetated next to a mountain bike trail. The Cross Country Mountain Biking World Cup is to be held at the resort in a week, and a large number of participants are in town early to practice. The bike department staff checks the course and requests that the maintenance crew fence off the treated area. However, the crew becomes sidetracked on another project and believes they still have five days until the race. When the lifts open for practice runs, the bikers, seeing an open area with a pine needle cover, use that area for warm-ups and as a shortcut to the lift. By the time the fencing is installed, the entire area is destroyed, requiring extensive and expensive re-treatment. The cost of the re-treatment is not even covered by the profit from the bike event.

Solution 2

When the soil-vegetation treatment was completed, fencing should have been installed immediately, eliminating any potential confusion and protecting the recently completed treatment area. Furthermore, signs should be put in place along the edge of the project explaining that it is an environmentally sensitive area and travel is prohibited.

Additional Suggestions

Where all other restoration elements are in place, post-treatment disturbance is often the one factor that causes project failure. Early planning to protect treatment areas and avoid disturbance pays off.

Toolkit

See Tool 15, ProtectingTreatment Areas, for additional information.

NOTES

SECTION 3: Performance Monitoring and Follow-up

This section describes practices that monitor or assess the effectiveness of site treatments. Monitoring or assessment informs the project proponents, regulators, and other stakeholders how the project is performing relative to success criteria. Monitoring can also suggest where additional treatment may be required before small problems become large. This information can directly help improve the design of future projects.

Guiding Principle 13: Performance Monitoring

Goal

To assess project performance in a quantifiable manner against project success criteria and to gather information for a number of subsequent uses, as described in Guiding Principles 14, 15, and 16.

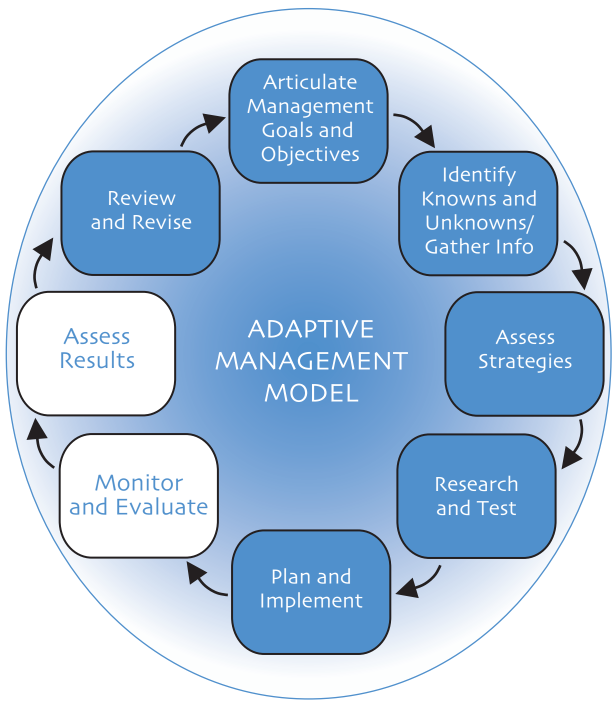
Description

There are three main types of monitoring:

- Compliance monitoring (meeting regulatory, especially water quality standards)
- Implementation monitoring (was the project implemented as planned? This type of monitoring is discussed in GP 7)
- Performance monitoring (how the project is functioning or performing)

It is this third type of monitoring that we are discussing here.

Performance monitoring should gather useful information relative to how well the project is functioning and whether it is meeting the project success criteria. Information or data should be quantifiable to the greatest extent possible. When quantified, information or data is less prone to subjective interpretation and thus argument. Visual interpretation is generally not very reliable. Well-prepared monitoring data and interpretation help the reviewer understand not only if success criteria are met, but also how the treatment area(s) are functioning.



Monitoring may include assessment of any or all of the following methods and parameters, depending on project goals and success criteria:

- Soil nutrients analysis
- Soil density (penetrometer measurement)
- Plant and mulch cover (cover point)
- Visible erosion
- Plant composition (e.g. native vs. weedy species)
- Bare areas
- Drainage and/or hillslope hydrology functions
- **Time**

Performance monitoring will determine whether success criteria are met and trigger management responses (see GP 3) when they are not met. Performance monitoring should also include a time element. A single point in time is rarely as useful as multiple assessments over time.

Example

A run-smoothing project is constructed on the Lower Left Out run of Inner Mongolia. Success criteria list, among other things, a requirement that no bare areas of greater than 15 square yards shall exist in the treatment area and that of the 300 shrub seedlings planted, a survival rate of 50% would be expected. Upon inspection, a large bare area was noticed as a result of a small surface slump. Further, in the nearby area planted with seedlings, only 40% had survived, some of which had been in the surface slump area. The erosion control manager, who had been tasked with inspection and success assurance, noted the problems in his monitoring assessment and report.

Solution

The success criteria included management responses to both of these issues. The bare area management response was to re-mulch and re-treat the area if indicated. Since only a slight amount of movement occurred, most of the soil amendment remained in place. Soil was moved back into place by hand some re-seeding was done, followed by mulching and irrigation. Since only 120 seedlings survived the winter and a plant census showed that two particular species had the best survival rates (85 and 70%), 75 individuals of those two species were planted and irrigated. When the USFS staff inspection took place three weeks later, the area was already showing a robust cover of young green shoots in the re-treatment area and the newly planted seedlings were showing good growth and new buds as well.

The results of this process eliminated the need for the USFS inspection staff to take any sort of action since the responsibility and initiative for action had been taken by ski area staff. Note also that the inspection showed that no sediment had moved below the temporary BMPs. The inspection was positive and non-confrontational.

Additional Suggestions

Latitude exists to develop and suggest monitoring protocols and procedures that may be less expensive and/or more accurate in determining project function for disturbed site treatment. For instance, cone penetrometer readings may provide more information about site erosion potential than cover-point monitoring. Work to determine which monitoring methods are most useful and cost-effective is being conducted by a number of entities.

Toolkit

See Tool 16, Monitoring, for information on specific monitoring tools and techniques.

Guiding Principle 14: Follow-up Treatment and Management Response

Goals

1) To address problem areas that fail to meet success criteria so that they can be brought up to acceptable levels (as defined by success criteria).

2) To apply additional resources (water, seed, fertilizer, etc.) that may be needed in subsequent seasons to assure the success of certain treatments.

Description

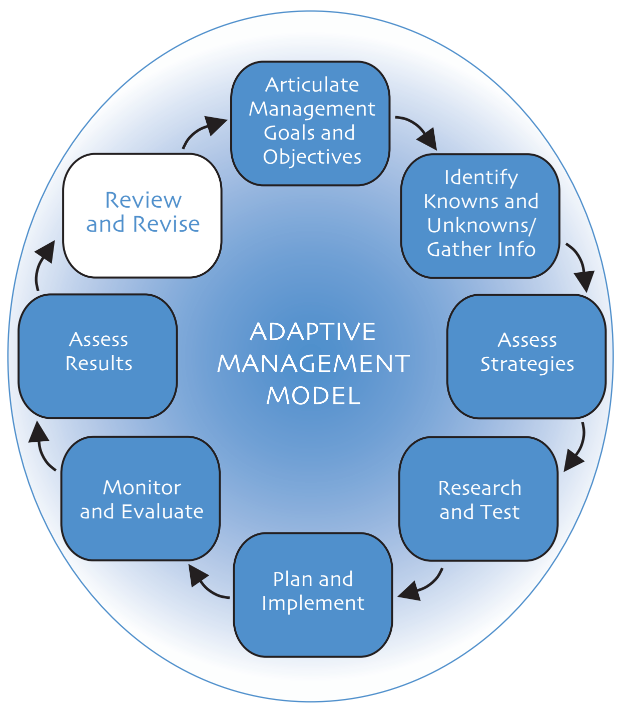
Follow-up treatments can reverse problem trends quickly and cost-effectively and can help a project reach the required level of function if the initial treatment doesn't accomplish the intended outcome. If left alone, small problems can become large and expensive problems to repair and/or result in ongoing watershed, water quality, and environmental degradation.

Example 1

A run-cutting project area is inspected the season following treatment. A small rill has formed and has carried water from above the run and at one point has resulted in a small rotational failure (mini-landslide). The inspector follows the rill upslope and finds that a water bar has filled with sediment and breached. The water bar has a slight level spot, which accumulated sediment, thus causing the breach. The water bar was re-shaped, the rill was hand tilled and re-seeded, and the rotational failure was rebuilt and re-seeded. All were irrigated.

Solution 1

The solution described in Example 1, while somewhat time-consuming, dealt with a relatively small problem. Left untreated, this trend would have resulted in a large gully forming which would also have run across a key service road, requiring re-engineering of the road as well as partial rebuilding of the run. A relatively small amount of work precluded a great deal of work later.



Example 2

A small road improvement project was completed and the road cut received an integrated soil-vegetation treatment. However, due to disturbance during the winter, a small area had no vegetation. The erosion control manager immediately re-treated the area and added irrigation.

Solution 2

The solution is contained in the treatment. If the manager had not paid attention to this area, it is likely that it would have begun to erode and ultimately become a problem requiring a high level of effort to repair, which would have been costly and may have resulted in additional road maintenance work as well.

Additional Suggestions

Follow-up treatment includes standard post-project treatments such as re-seeding, re-tilling, supplemental irrigation, and fertilization. Most projects are more cost-effective when follow-up treatments such as these are minimized and/or employed for as short a time as possible. If an area needs ongoing irrigation or fertilization to maintain success, once expensive follow-up treatments are ended, the site is likely to revert back to low plant cover and high runoff potential.

NOTES

> "If you can't explain it simply,
> you don't understand it well enough."
> – Albert Einstein

Guiding Principle 15: Future Project Improvement

Goal

To use information and data from existing and past projects to improve future projects.

Description

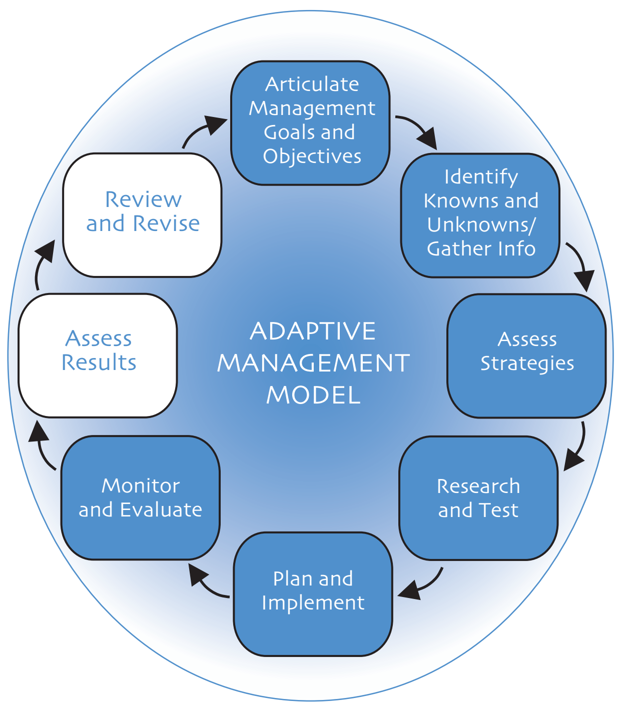
When gathering information from existing projects (see GPs 7 & 13), that information, if assessed and processed properly, can be used to improve the effectiveness and success of future projects. This is especially true if experimental or test elements have been included. With good documentation (i.e. as-builts), successful treatments can be replicated and modified. Treatments that haven't worked as expected can be eliminated or adjusted for future projects. In fact, many projects that don't meet success criteria hold great potential for improving practices as project managers adjust, alter, and change those practices.

Example

Hydroseeding and fertilization with ammonium phosphate or ammonium nitrate (16-20-0) has been used in ski resorts and other treatment areas for more than twenty years. No goals, success criteria, or monitoring have been applied on most of those projects. Current monitoring is showing that most hydroseeding projects and other types of surface treatments on drastically disturbed slopes have not reduced erosion to acceptable levels.

Solution

Clearly stated goals and monitoring linked to appropriate success criteria would have allowed project inspectors to recognize that many of those surface treatments were not producing desired plant cover or effective sediment source control. Appropriate monitoring and feedback could have provided information for project improvement. The guiding principles described in this handbook are designed to fill that critical gap.



Additional Suggestions

Collecting data and information on projects should go beyond simple data collection. Information and data are put to their highest use when they are used to improve existing and future projects.

Guiding Principle 16: Information Sharing

Goal

To share useful project information so that other project planners, implementers, and assessment personnel can improve their practices.

Description

Where information can be shared effectively, the information benefits the environment and others doing similar work. It can result in significant cost savings through improved project performance, reduction in "reinventing the wheel," and the increased synergy that is generated from creative interaction between practitioners. This commitment to share information brought the CAREC team together and has driven the production of this document. This step assumes that environmental improvements are likely to be universally beneficial and not limited by proprietary processes.

Information distribution can take many forms such as web-based distribution, professional societies or group meetings, trainings, newsletters, and so on. If tracked efficiently, information sharing improves the state of the art in sediment source control, thus benefiting all participants environmentally and economically.

Example

A ski area employee has just been appointed head of erosion control. Reading a trade publication, she begins to assume that hydroseeding is the most powerful and effective erosion control treatment on the planet. A magazine article shows two people and a car that had all been hydroseeded and were completely covered in grass. She contracts with a local hydroseed specialist to seed an eroding run for the sum of $2,000/acre, a relatively reasonable price. The following season, no vegetation is established and the new manager must defend her job. Photos from the magazine article are no longer convincing!

Solution

The manager goes onto the web to a newly developed CAREC website that lists local results of a number of erosion control field tests. She sees that in high alpine situations on her soils, hydroseeding produced inconsistent and typically poor long-term results. However, a more expensive "integrated soil treatment" had been shown to completely eliminate runoff and thus eliminate erosion in rainstorms up to 5 inches per hour for the three monitoring seasons to date. She quickly calculates how many times she would have to hydroseed to equal the cost of the soil treatment. She reasons that four hydroseed treatments would roughly equal one integrated soil treatment. She implements this treatment and achieves success and, since the results are verified the following season, solidifies her job as well.

Additional Suggestions

Information sharing is challenging since most practitioners are extremely busy getting their normal work accomplished. However, when information sharing is efficient, work will be more effective since practitioners will not have to treat the same site multiple times. Information sharing systems require time, funding, commitment, intention, and participation. Through the CAREC process, we have clearly identified the need for such an ongoing process or processes.

Visit the Sierra Business Council web site (www.sbcouncil.org) for information-sharing opportunities.