3.12 Plant Protection and Establishment

This section explains additional cultural techniques for protecting and establishing vegetation. These techniques, including mulching, irrigation, and devices to protect plants from wildlife damage, often are critical to the success of restoration projects.

3.12.1 Mulching

Mulch is material placed on the soil surface or around transplants to prevent erosion and to protect plants from heat, cold, and drought. Mulch includes loose materials such as straw, native hay, rock, or wood chips and products made into mats from a variety of materials (figure 3–134). Mulches must be installed securely in close contact with the soil to work well. Vertical mulches are installed upright to cast shade and to protect plants from the wind.

3.12.1a Advantages and Disadvantages of Mulching

The advantages of mulching include:

- Reducing erosion substantially by deflecting the impact of raindrops, reducing the velocity of moving water, and serving as miniature checkdams to hold soil in place.
- Increasing soil moisture by reducing evaporation and increasing water infiltration.
- Protecting germinants and plants from too much heat in the summer by reducing soil temperatures.
- Protecting plants from frost heave and needle ice in the fall by maintaining warmer soil temperatures.
- Providing some organic material for soil building.
- Protecting plants from wind.
- Preventing soil from crusting and recompacting.
- Improving soil structure, allowing soil microorganisms to recolonize.
- Protecting plants from solar radiation.
- Preventing weed establishment if the layer of mulch is thick (but also preventing native seed from germinating).
- Preventing birds from eating seed.
- Trapping seed on the site.
- Demonstrating to visitors that “Something is happening here.”

Because of these benefits, mulching can increase germination rates, seedling survival, and plant growth. For example, Mount Rainier National Park compared germination and establishment of native species in the subalpine zone using a variety of mulches. Their findings (table 3–14) show the relative benefits of using mulch.
Table 3–14—Seeding success after 1 year, comparing different mulch materials in the subalpine zone at Mount Rainier National Park (Rochefort 1990).

<table>
<thead>
<tr>
<th>Mulch</th>
<th>Seedlings per square yard (per square meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw blanket</td>
<td>451 (377)</td>
</tr>
<tr>
<td>Curlex</td>
<td>292 (244)</td>
</tr>
<tr>
<td>Rollite</td>
<td>258 (216)</td>
</tr>
<tr>
<td>Native sedge</td>
<td>87 (73)</td>
</tr>
<tr>
<td>No mulch</td>
<td>48 (40)</td>
</tr>
</tbody>
</table>

In some cases, mulching makes no difference in success. Mulch may actually be detrimental, depending on the type of mulch. Mulching also increases the project’s cost.

The disadvantages of mulch include:

- Keeping some soils too cool in spring, such as those in alpine fellfields. Thinner mulch or a darker mulch will help raise spring soil temperatures.
- Inducing premature germination without adequate water to support the germinant. Covering seeds with soil will prevent this problem.
- Decreasing establishment of some species. For example, in a native bunchgrass community, a 50-percent cover of native grass mulch suppressed seedling establishment (Belnap and Sharpe 1995).
- Increasing susceptibility to fire, because some mulch materials, such as jute and straw, are highly flammable (a spray application of monoammonium phosphate fertilizer will serve as a fire retardant).
- Creating cover that allows rodents and insects to eat seed without being exposed to predators.
- Reducing soil nitrogen levels because of decomposition if organic mulch materials are mixed in with the soil.
- Increasing weed problems, because straw mulch can have both grain seed and other weed seed mixed in. Even certified weed-free straw can have a small percentage of noxious weed seed and any amount of other weed seed. Rice straw is a good alternative because rice will not grow on dry soil, nor will the aquatic weeds associated with rice grow on dry soil.
- Preventing moisture from reaching the soil in areas with very light rainfall.
- Preventing native seed that drops on top of mulch mats from establishing when it germinates.
- Persisting in some environments because mulches can degrade slowly in certain conditions.
- Trapping animals in the net that covers some mulches.
- Slowing seed germination and seedling growth in the subarctic.

3.12.1b Selecting a Mulch

Mulch should be selected to mimic the structure and function provided by the natural litter layer. For example, a meadow normally would have dead leaf material that serves as a mulch. That material not only would regulate soil temperature and soil moisture, but would add nutrients to the soil as it decomposes. A straw or natural fiber mulch would mimic this condition. In a desert or alpine fellfield with little leaf litter, rock tends to serve as mulch.

The type of mulch selected and the application rate will depend on conditions at the site, such as slope, erodibility, soil temperatures, moisture, wind, the potential for weed infestations, and the potential that wild animals might cause damage. Cost will be a factor, but because of the labor-intensive nature of work at roadless locations, the cost of mulch is often insignificant. As with the other aspects of project planning, it is a good idea to consult with other practitioners who have worked in similar environments or with the same species of plants to learn the mulches that are the most effective. Be open to experimentation; studies of mulching in similar environments have yielded seemingly contradictory results.
3.12.1c Comparison of Different Types of Mulch

Mulches used at remote roadless sites are composed of native materials or of materials that will degrade naturally. They can be installed without motorized tools. A number of nondegradable mulch materials are used extensively in reclamation projects outside wilderness, but because of their long-lasting unnatural appearance and because they are less effective in controlling erosion, these materials will not be discussed (Harding 1990; Theisen 1992). Hydromulching, which requires a truck-mounted sprayer system, also will not be covered here, but is a common mulch used for road projects along roads in temperate areas.

Native Hay or Leaf Litter

When an area has enough grass and forbs, native hay can be cut with a sickle (figure 3–135) or a scythe or raked up with a thatching rake. Native hay provides an additional source of seed. Leaf litter can be collected from adjacent areas, taking care to not collect too much in one area. Because native hay shrinks as it dries, it takes a lot of hay to provide an adequate mulch layer. Native hay or leaf litter will wash or blow away unless it is crimped into the soil with a shovel, or anchored with a tackifier, photodegradable nylon net, or jute. Collecting native hay or leaf litter takes a lot of time, so plan for increased labor.

Native Rock

Although it may seem improbable, rock can make an excellent mulch with a natural appearance. If the project site would have been rocky before disturbance, consider using rock as a mulch and to improve the area’s appearance (figure 3–136). Rock will provide sheltered microhabitats where
plants can reestablish. Larger rocks provide shade and may funnel rainfall to plants. Some projects have used gravel up to an inch thick as imported mulch. This technique is especially important in arid lands (Bainbridge and Virginia 1990) and in sparsely vegetated alpine environments, such as fellfields (Rochefort 1990). Rock also can be incorporated with other mulches. If you are collecting local rock, avoid overcollecting from any one spot. If you are importing gravel, make sure that the source is free of weed seed or have the gravel cleaned before using it (monitor the site for weeds after planting).

**Straw**

Loose straw is the most common mulch used on large-scale restoration projects because it is effective, inexpensive, and easy to apply with machinery. The longer the stem, the more effective straw is as mulch. Seedling establishment has been high on many projects that used straw mulch. On slopes or windy areas, straw must be crimped into the soil or anchored in the same ways as native hay. Straw decomposes within 1 to 3 years. It may not be the best choice for a site that needs long-term protection.

Usually, about 2 tons of straw is applied per acre (0.09 metric ton per hectare), providing about 66- to 100-percent cover that is about 2 inches (50 millimeters) deep. Applications vary from 1 to 8 tons per acre (0.45 to 3.56 metric tons per hectare) when straw is crimped into the soil (refer to section 3.4.8c, Crimping). For seedlings to germinate and become established, soil needs to show through the straw. A heavier application of straw will help suppress weeds and keep the soil cooler. If the introduction of weedy species is a concern, rice straw is best. It is a byproduct of rice grown in California.

**Bark or Wood Chips**

Bark or wood chips work well as mulch on arid lands where the high carbon-to-nitrogen ratio (expressed as carbon: nitrogen) minimizes undesirable nutrient inputs into the soil (Bainbridge and others 1995). On projects that require higher fertility, the carbon:nitrogen ratio of bark or wood chips could be a problem. Richard Miller, Forest Service soil scientist, suggests that for a 1- to 2-inch- (25- to 50-millimeter-) thick layer of wood mulch, 50 to 100 pounds (23 to 45 kilograms) of nitrogen fertilizer should be applied. If the nitrogen is in the form of urea, twice that amount would need to be applied during rainy weather to prevent losses to volatilization (Potash and Aubry 1997). Wood chips may blow away or be washed downhill by surface water.

**Jute Netting**

Jute is made from a heavy hemp fiber woven into an open net (figures 3–137a and 137b). Jute is easy to apply and is less expensive than erosion-control blankets. Jute only...
provides moderate erosion control, so it is less effective in areas with runoff. Because of its open weave, it does not provide the benefits of mulch, but it does allow natural seeding to occur. Jute is highly flammable.

**Erosion-Control Blankets**

Erosion-control blankets are generally a layer of straw, wood shavings, coconut fiber, or paper stitched through to hold the mulch in place, or sandwiched between layers of net, before being compressed into a roll. Some product lines combine mulch materials, such as straw, with wood shavings. Except for the straw products, erosion-control blankets should protect plants without adding weed seed to the site. Erosion-control blankets are the most expensive type of mulch, but their cost may be insignificant, given the total project costs at some wilderness and remote sites. Numerous companies make the erosion-control blankets described below. See chapter 5, *Tools of the Trade and Other Resources*, for a detailed comparison of various biodegradable erosion-control blankets, as well as sources where they can be purchased.

The advantage of erosion-control blankets over loose mulch materials is that the blankets can be anchored easily to prevent them from blowing or washing away. Blankets are installed according to the manufacturer’s instructions, overlapping their edges by about 4 inches (100 millimeters), and using metal pins to hold the matting down. Rocks or limbs also can be used to help anchor the blanket and break up the blanket’s unnatural appearance. If blankets are not installed properly, they can injure seedlings. A chain saw can be used to cut a roll into narrower widths. For example, sometimes half the width of a 4-foot (1.2-meter) roll is just right for mulching a closed trail.

**Types of Erosion-Control Blankets**

**Excelsior Blankets**—Excelsior blankets (figures 3–138a and 138b) made from aspen shavings have been used extensively on subalpine restoration projects. Excelsior blankets hold in soil moisture and have been advocated for dry sites, such as exposed ridges. The unnaturally bright color of the wood shavings can be alarming when the blanket is first unfurled, but the blanket turns gray after a season or two of sun, rain, and snow. In subalpine environments, the wood fibers last just a few years; a second application may be needed to continue protecting the site.

**Coconut-Fiber Mats**—Coconut-fiber mats (figures 3–139a and 139b) have a natural-appearing brown color and have been used successfully in a number of environments. At Denali National Park, coconut mats are lifted gently as soon as the dicotyledon species, such as legumes, have germinated. The mat is reused (Densmore and Vander Meer 1998).
Figures 3–139a and 139b—Coconut Man sports a wig showing off the dark brown color of a freshly unfurled coconut fiber erosion-control blanket (top). At this subalpine site, the coconut matting had begun deteriorating (bottom) 4 years later.

**Rollite**—Rollite, a brown paper mulch, has been used successfully on alpine sites. Its dark color absorbs radiant heat. Because the blanket is thin, the soil beneath it can warm. The stitching on this product does not readily decompose. This product no longer appears to be on the market, but it is mentioned here to acknowledge the value of a thin paper product for alpine sites.

**Single Portable Mats**—Single portable mats have been developed for tree seedlings. These mats could benefit seedlings on a site that does not need erosion-control measures. Black plastic mats suppress vegetative competition, but other biodegradable mats have been developed as well (Windell and Haywood 1996).

**Vertical Mulch**

Vertical mulch is upright mulch, placed southwest of the plant to block the most intense sunlight or in another location to block the prevailing wind. Vertical mulch also provides a place for seed to lodge, funnels rainfall toward its base, and offers protection from trampling or from grazing wildlife (Bainbridge 1996). Vertical mulch can be rock, dead branches, logs, or tufts of straw. Even salvaged plants that die when they have been transplanted continue to serve as vertical mulch (Patterson 1997). Shade cards could be considered a form of vertical mulch.
### A Note About Photodegradable Nets

Polypropylene nets can be manufactured with varying amounts of ultraviolet light inhibitors, allowing them to decompose at differing rates. Nets generally break down within 1 to 5 years. More time is needed for decomposition of the little pieces of polypropylene where the cells join. Pieces remaining on the soil are decomposed by soil micro-organisms that convert them to carbon dioxide and water. A number of projects have reported problems with birds, snakes, or rodents getting tangled in the nets and dying. In other areas, this has not been a problem. If animals frequent the project location, this type of net should be avoided or removed after it has served its purpose. Some practitioners remove the net by the second year, after snow and rain have compressed the mulch and made it more stable. Before buying a product with stitching or a net, ask whether the net will degrade. In some cases, the net will be permanent.

### 3.12.2 Irrigation

Some projects will not require additional irrigation after seeds have been sown or seedlings have been transplanted. The need for irrigation can be determined based on projects that have been successful, or unsuccessful, with the same plant species in similar environments. Many projects water plantings periodically during the dry portions of the first growing season to help seedlings become better established. Most practitioners advocate tapering off watering as soon as root systems are established so plants adjust to their environment.

If irrigation is not feasible, plant species may be selected based on their drought hardiness. Landscape-scale reclamation treatments, such as mine reclamation or reforestation, eliminate the need for supplemental water by planting inoculated locally-adapted species with an adequate root-to-shoot ratio, planting them correctly, and planting them at the proper time. Moisture-retention techniques such as imprinting, pitting, mulching, and the use of tree shelters or shade cards may be employed. Overplanting to allow for some mortality may be less expensive than establishing a regular watering program (Burke 1998).

Irrigation assures maximum initial survival of plantings, extends the planting season, allows less drought-tolerant species to be planted, and promotes germination of seeds (Redente 1993).

The disadvantages of supplemental irrigation include the added labor and expense, the possibility that plants will be killed by overwatering, and the possibility that plants will grow shallow roots that may not allow the plants to survive when watering ends (Redente 1993). Surface watering may cause weed seed to germinate, and the weeds may outcompete native plants. In addition, surface irrigation may favor some species, such as grass, that outcompete other desired species, such as shrubs.

In the Mojave Desert, just 2 percent or less of the plants that did not receive supplemental irrigation have survived (Bainbridge and others 1992). Clary and Slayback (1984), on the other hand, determined that irrigation did not increase the survival of most Mojave Desert shrub species if they were planted during the late winter or early spring. Practitioners working in the sagebrush steppe have demonstrated that supplemental irrigation increased initial establishment and plant growth, but that after 4 years there was no difference between plants on irrigated plots and unirrigated plots (Doerr and others 1983). Some practitioners working in subalpine environments advocate watering plantings every few days during the dry portion of the growing season (Campbell and Scotter 1975; Hanbey 1992; Hingston 1982). Arid land restorationist Edith Allen (1993) suggests watering no more than would occur during a wet year.
If you do water plants, provide enough water to reach the deepest portion of the root zone, stimulating the root system to grow deeper rather than stimulating it to produce roots close to the soil surface. Deep watering can be achieved by repeated waterings or by leaving a drip system going for a longer period of time. For plants with deep root systems, the deep pipe method may be appropriate to deliver water straight to the lower portion of the roots.

### 3.12.2a Water Delivery Systems

Many techniques have been devised for catching water, moving it to restoration sites, and administering it to plants. Practitioners who apply a little ingenuity will probably think up a few more ways.

**Hand Watering With Watering Cans**

Watering cans are probably the most common tool for watering plants on remote sites. Watering cans can be filled in lakes or streams or in larger containers of water. David Bainbridge advocates using French watering cans because the long arching handle on this type of watering can is easy to balance (figures 3–140a and 140b). Usually, water is applied directly to the base of plants, taking care not to flood the rim of the planting depression.

**Clay Pots**

In arid regions of Africa, unglazed, low-fire clay pots, such as terra cotta pots, are placed in the ground beside plantings with their rims near ground level. Water in the pots will seep slowly through the porous clay. Pots are refilled every 2 to 4 weeks, a time-consuming process. The drain hole in the bottom of the pot is plugged with silicone. A ceramic saucer or aluminum pie tin is placed upside down on the pot (as a lid) and weighted with a rock. Perforations in the lid will allow rainwater into the pot. The lid prevents evaporation and keeps animals from drinking the water or from drowning.

This method has met with success in arid environments. It works well in sandy, gravelly, or saline soils. The clay pot also helps filter saline water. After several years, the porosity of the pot decreases, but the porosity can be restored by reheating the pot.
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**Catchment Basins**

This method lends itself to areas that require earth moving as part of site preparation. Large dish shapes, 30 feet (9 meters) in diameter or larger, are sculpted into the soil. These basins will prevent water from running downslope.

**Deep Pipes**

With this method, a long pipe 1 to 2 inches (25 to 50 millimeters) in diameter is driven into the ground beside the planting hole. Holes drilled in the side of the pipe next to the plant allow water to seep into the soil. This method is best for plants with deep root systems and requires much less water than other systems; 1 quart (0.95 liter) of water applied using this technique is equivalent to several gallons (about 12 liters) applied at the surface. In addition, plants often can tolerate saline water applied using this technique that they could not tolerate if the water was applied with surface watering.

Pipes can be 1 to 4 feet (0.3 to 1.22 meters) long, depending on how deep the plant’s root system will grow. Perforations need to begin near the level of the transplant’s lower roots and be spaced to the bottom of the pipe. PVC pipes last well, but may be difficult to remove if roots grow into the pipe through the holes. Thick paper tubes won’t have to be removed, but may degrade too quickly. Pipes have a lid on top to keep out animals and debris. A lid made from screen will allow water to be poured through the lid. Pipes can be filled from a watering can that has its sprinkler head removed, or from an emitter sprinkling system.

**Drip and Sprinkler Systems**

Drip and sprinkler systems are installed with a network of hoses that deliver water to the site. Smaller hoses are placed at the base of individual plants or connect to sprinkler emitters that water a portion of the area. These systems may not be well suited for restoration projects because they require frequent maintenance:

- Sprinkler heads clog easily even when they have a good filter.
- Animals chew on the tubing.
- Ultraviolet light breaks down the plastics.

Unless the water is directed into deep pipes or allowed to run for long periods, it tends to stay near the surface, producing shallow-rooted plants. On arid land projects, sprinkler systems should be avoided because rapid evaporation will leave salts that are toxic to plants on the soil’s surface.

Nursery and garden supply businesses carry irrigation supplies. The gravity-fed water systems used for firefighting can be modified to provide water for irrigation. Doing so involves a gravity sock placed in a creek or a porta-tank upslope that is connected to a sprinkler system or a series of hoses and a nozzle. These systems clog with sediment frequently, requiring regular maintenance.

**Tree Shelters and Plant Collars**

Tree shelters and plant collars are made of pipe, peat, waxed cardboard, or plastic. They are set into the ground during planting and protect plants from direct sun, grazing animals, trampling, and sand blast. Water can be poured directly into the shelter or collar. Arid land restorationist Jayne Belnap suggests watering at the rate of 1 quart (0.95 liter) every 2 to 3 weeks (Belnap and Furman 1997).

**3.12.2b Obtaining Water**

Irrigation water has to come from somewhere. This can be a problem at roadless restoration sites that do not have surface water nearby. Water can be flown or packed in to remote sites, but the possible expense, resource damage, and wilderness philosophy argue against this option.

Options for storing water include food-grade barrels retrofitted with a spigot and timer, or porta-tanks.

**3.12.2c Superabosorbent Polymers**

Some practitioners, especially in arid environments, have experimented by adding superabosorbent polymers (used in disposable diapers) to the soil when planting. The polymers absorb many times their weight in water, increasing the amount of water retained in the soil. Unfortunately, the polymers may limit root growth by holding water rather than
3.12.3 Preventing Animals From Damaging Plants

At some locations, animals that munch on vegetation or bark can quickly destroy the chances for restoration success. At other locations, animals are not much of a problem. Consult with local practitioners to determine whether plants need to be protected from animals and to learn of strategies that have been successful. The methods described below have been used with varying degrees of success.

3.12.3a Protective Coverings

Wire cages, tree tubes (figure 3–141), row covers, and tree wraps can protect a plant until it becomes established. Wire cages can be made from chicken wire. Tree tubes are available through forestry supply catalogs, and row covers and tree wraps are available through nursery supply catalogs.

3.12.3b Reduced Fertilization and Irrigation

Animals are attracted to the additional nitrogen in the tissues of fertilized plants. Cutting back on fertilization before outplanting will help, as will refraining from additional fertilization once seedlings have been planted. Animals also are attracted to well-watered plants. Reduce or stop additional irrigation once seedlings have been outplanted.

3.12.3c Animal Repellants

Bitter or hot animal repellants can be sprayed on foliage. Repellants need to be applied before animals discover the plants. Repellants will wash away during rain storms. A systemic repellant is available that can be added to the soil during propagation. This repellant will remain in the foliage for up to 5 years after treatment.

3.12.4 Signs

For most situations, signs will be needed to keep visitors from using your restoration site. Signs can be made of wood, Lexan, or Carsonite, a composite made from glass-fiber reinforced polymers. Match the type of sign (figures 3–142a, 142b, 142c, 142d, and 142e) to the setting and the type of user.

Even though we would like to think of signs as temporary, they probably will be needed over the long term unless the type of use has changed. Some people just won’t get it (even with the sign). A good option for wilderness is a standard routed oak sign mounted on a short post or a tree. Use wording such as “Closed for Restoration.” Refer to chapter 5, *Tools of the Trade and Other Resources*, for information on ordering Lexan signs.
In addition to signs at the restoration site, consider whether you need a poster at the trailhead or another location where visitors first enter the project area. The small information sign shown in figure 3–142d was left at the project area for several years to give plants in the restoration sites a chance to become established and to help campers find the designated campsites. The larger sign board (figure 3–142e) has been installed for many years and has undergone many revisions to help the public understand the information.
3.12.5 Regulations
Regulations are covered in detail in chapter 2, *Planning for Restoration of Small Sites in Wilderness*. At a minimum, a special order is recommended to prohibit entry into restoration sites. Rather than writing an order specifically for your project location, see if this prohibition can be in an order that applies to the wilderness or forest. Forest Service and Bureau of Land Management employees can obtain a good example of such an order from the Mt. Baker-Snoqualmie National Forest’s Web site on their internal computer networks at http://fsweb.f5.r6.fs.fed.us/fs/orders/multi-forest/. The four national forests of the Washington Cascade Range have a shared order that prohibits entering a signed restoration site.

3.13 Documentation, Monitoring, and Adaptive Management

*Figure 3–143—Good documentation of restoration treatments is critical during monitoring. Intern Alexis Bachrach was able to satisfy the requirements for her college senior project by serving on a restoration crew and preparing the project documentation.*

Monitoring project success is easy to overlook in restoration plans, but should be part of any restoration project, even at the planning stage. This is especially true given the highly variable and often experimental nature of restoration. Slight differences in site microclimate, soil chemistry, timing of field work, or perhaps even passing weather conditions can cause radically different results, even when nearly identical methods are used.

Monitoring may detect problems while there is still time to correct them and will provide a long-term record of results that others can refer to. Depending on the need and your budget, monitoring might be fairly simple (figure 3–143) or quite detailed. Monitoring might be qualitative, quantitative, or both.

In this section, we will explore different levels of monitoring performed by the Forest Service on restoration projects. We will consider factors involved in designing a monitoring program. Finally, we will review a simple monitoring protocol and suggest resources for selecting and designing more complex monitoring protocols. Sample monitoring forms are included in appendix E, *Forms*.

3.13.1 Adaptive Management

The goal of monitoring is to gain the understanding needed for a better job of management. Monitoring may result in midcourse corrections (figures 3–144a and 144b) to prevent further deterioration or to improve restoration success. If users continue to enter a restoration site for example, barriers or signs may need to be improved, or enforcement of regulations may need to be increased. Monitoring may show that excess water running through a
site needs to be addressed. A failed planting may require another planting using a different approach or under different conditions. The key to adaptive management is taking new information, quickly devising a more successful strategy, and implementing it.

**Figures 3–144a and 144b—**This restoration site, first planted in 1980, started as a bare, compacted, and eroded slope. The site was treated with soil scarification, wildling plugs of partridgefoot (*Leutkea pectinata*), and jute netting. In the late 1980s, the site was reworked by scarifying soil between the plugs, adding rock for microhabitat and erosion control, and adding a layer of excelsior erosion control blanket. By 1993, when this photo (top) was taken, the partridgefoot was spreading. The erosion-control blanket prevented about 2 inches (50 millimeters) of additional soil loss (bottom).

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**Defining Validation, Implementation, and Effectiveness Monitoring**

The Forest Service’s *Land and Resource Management Planning Handbook* (FSH 1909.12) defines three levels of monitoring, each with slightly different objectives.

**Validation Monitoring**

Validation monitoring determines whether the initial data and assumptions used in development of the plan are correct. It examines the validity of standards and guidelines that drive prescriptions or activities.

**Implementation Monitoring**

Implementation monitoring determines whether plans, prescriptions, projects, and activities are implemented as designed. It examines the quality of the field work application of the project plan.

**Effectiveness Monitoring**

Effectiveness monitoring determines whether plans, prescriptions, projects, and activities are effective in meeting their objectives. It compares the work accomplished to the project’s short- and long-term objectives.

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**3.13.2 Determining Levels of Monitoring**

Anyone developing a monitoring plan or procedure for restoration projects should have a clear idea of the levels of monitoring that are needed and the degree to which they should be emphasized. If plans for the project were based on little or no field experience, validation monitoring may be a high priority. Likewise, if work is being done under contract or by volunteer crews, implementation monitoring may be an area of concern. A high level of effectiveness monitoring should be included in any restoration project. Because most
restoration projects won’t be completed for many years, effectiveness monitoring allows procedures to be adjusted to fit site-specific conditions. Effectiveness monitoring is an integral part of implementing the project activities.

**Determining the Need for Validation Monitoring**

Validation monitoring should be included to the extent that the project can be used to validate the standards and guidelines that have driven the project. The monitoring should include a sound accounting of the project’s scheduling, materials, and so forth, as well as an accounting of any significant difficulties or constraints that arose. This might involve simply taking notes or preparing a narrative summary of the project’s progress, or it may involve a more formal analysis.

Validation monitoring is especially important if the restoration project is responsive to a land-management plan or other decisions that were based on an environmental impact statement. In cases where a project cannot reasonably achieve objectives set forth in a land-management plan, validation monitoring may dictate further NEPA analysis, such as a forest plan amendment. Monitoring may provide the feedback needed to correct policy or regulations.

**Determining the Need for Implementation Monitoring**

Implementation monitoring will depend on the amount of detail used in planning the project, as well as the degree of flexibility built into the plan. This kind of monitoring requires that the project plan include fairly detailed specifications, especially for structural work such as constructing checkdams, backfilling eroded areas, installing erosion-control netting, and so forth. In essence, implementation monitoring can be seen mainly as inspection to ensure the quality of work. The inspection should be used to ensure that the end product meets objectives, not merely to show how and where the project fell short.

Particularly when working with volunteers, Forest Service crews, or other groups without a formal contract, implementation monitoring can be used to adjust specifications during implementation of the project. Doing so is especially important when workloads prove greater than anticipated, weather prevents work from being accomplished, or other problems arise. In general, the greater the scope and complexity of the project, the greater the importance of implementation monitoring.

**Determining the Need for Effectiveness Monitoring**

Typically, monitoring restoration sites entails monitoring the condition of site vegetation. The methods of monitoring or the indicators selected will vary with the type of vegetation involved and the techniques used to reestablish natural vegetation, as well as with the overall goals and objectives of the project.

The scale of the project will determine to some extent the kinds of monitoring techniques that should be employed. For smaller projects, it may be feasible to take detailed data on every plant on the site; for larger projects, permanent plots or random sampling techniques may be preferable.

The species of plants involved may dictate certain methods of monitoring. For example, different monitoring strategies might be employed when working with trees rather than grasses. With grasses, percent cover may be an excellent indicator of success, while with trees, height may be a better indicator. When direct seeding is used, a good indicator of success might be the number of stems per square foot or square meter. Percent survival would be a better indicator of success when planting plugs (figure 3–145).

Some possible indicators commonly used by ecologists include: total percent cover, percent cover by species; plant height; number of stems per given area, stem diameter, stem or plant size class, and survival rates for plugs or seedlings. Some indicators are more qualitative in nature, such as lists of species composition or classification of plant vigor. Although quantitative measures are more commonly used in monitoring, qualitative measures, such as vigor classification, can be very important. Standard vigor classification schemes can indicate whether plants are able to produce viable seed,