Figure 2–10—Information on bulletin boards can help visitors learn what's expected of them in wilderness. Photos or maps help draw visitors in for a closer look at the materials.

2.1.12c Intensive Site Management

Intensive site management includes a variety of direct controls: using regulations to require visitors to practice low-impact techniques for wilderness travel, redesigning the area to stabilize impacts and concentrate use, and actively restoring damaged soil and vegetation. The techniques discussed for each of these controls will focus primarily on correcting damage to soil and vegetation. Other problems identified through monitoring and the site assessment process may require additional solutions.

2.1.12d Regulations and Enforcement

Chances are that some regulations may already be in place to reduce impacts to soil and vegetation. Perhaps these regulations have worked in part, but have not allowed the area to reach the appropriate objective for management. It may be necessary to alter regulations or put additional regulations into place. Regulations mandate low-impact behavior in situations where visitors may not normally choose such practices. Regulations are unlikely to succeed without enforcement (figure 2–11).

Figure 2–11—Regulations enforced by rangers can help reduce damage caused by visitors in wilderness areas. Regulations might apply to the entire wilderness, to a series of wilderness areas, or to specific locations.

When considering new regulations or changes to existing regulations, consider the potential that users and their impacts could be displaced. Would this displacement be acceptable? If displaced users meet their needs close by, the impacts will show up close to your project area. They might camp in the next basin over. Perhaps they will seek similar destinations elsewhere or choose another favorite place. Some visitors will seek out completely different wilderness areas, perhaps in other States, where they are less regulated. Visitors displaced from the Enchantment permit area of the Alpine Lakes Wilderness in Washington said they would adopt all strategies discussed above, making it difficult to pinpoint a specific effect of displacement (Shelby and others, no date).

2.1.12e Regulations To Reduce Use Directly

Any regulation may result in an indirect decrease in use if the user would rather go elsewhere than endure the regulation. However, some regulations may reduce overall use directly without actually limiting the number of groups that enter the area. Examples include:

- **Limiting Group Size**—A group size limit (for people and/or stock) can be set based on levels that are sustainable for the campsites, stock-holding areas, and available forage. Larger groups have more impact, especially when their activities spread onto vegetated areas and their social interactions require lots of travel back and forth. Some areas of a wilderness may require a lower group size than other areas. Regulations limiting group size can be very effective if they are combined with low-impact practices. Large groups will be displaced to areas of wilderness that allow larger groups or to other backcountry areas.
- **Limiting Length of Stay**—Many national forests already limit the length of stay (2 weeks is quite common). At a popular destination, a shorter length of stay may prevent crowding while giving more persons an opportunity to visit.
- **Prohibiting Certain Uses in an Area**—An area may be closed to a certain type of use, such as all stock use, overnight use with stock, or any overnight use altogether.
- **Modifying the Location of Use**—Some possibilities include requiring the use of designated campsites, prohibiting use at closed sites, or having a camping setback from a lake or desert waterhole.

It is important to have a clear understanding of why a site should be closed. Is it to allow access to a day-use area? To improve the view for others? To reduce campsite intervisibility? To prevent further damage?

Closing a site may or may not fix a problem. Sites are unlikely to recover on their own unless they are impacted only lightly or are located in the lushest of environments. Malcontents may remove signs in closed sites and then say, "We didn't see a sign."

Designated sites help concentrate impacts (figure 2–12). Designated stock camps and areas to hold stock are an excellent way to concentrate stock impacts.

There is less incentive for campers to remove a sign that designates a campsite, because once the sign is gone they can no longer camp there. Any area that charges a fee for entry incurs more liability for environmental hazards, such as falling trees. If a campsite is designated, forcing a visitor to use it, liability issues may become an increased concern.

Figure 2–12—Signs telling campers where they're welcome to camp aren't as likely to be pulled up and thrown into the bushes as signs telling campers where not to camp.

Camping setbacks should be considered only when adequate and appropriate places exist to camp outside the setback. Tragically, the number of impacted sites doubled at many wilderness lakes after setbacks were instituted. These sites heal slowly, even with active restoration. Setbacks are common and ecologically important in desert areas where wildlife need undisturbed access to limited water.

Stock setbacks can be used to protect fragile areas, such as shorelines. The national forests in the Washington Cascades implemented a 200-foot (about 61-meter) setback from all lakes and ponds; stock can be within this area only if they are being led to water or passing by on a trail. This practice also reduces user conflicts.

2.1.12f Regulations To Reduce High-Impact Behaviors

Examples of regulations that can be used to reduce or eliminate high-impact behaviors include:

- **Prohibiting Campfires**—Combined with limiting group size, prohibiting campfires may be the most important regulation to reduce impacts to vegetation and soils. Campfires thoroughly alter soil qualities, making revegetation very difficult. Even in areas where a firepit is considered an acceptable impact, firewood gathering creates many additional impacts. Users create social trails while they are scavenging for wood. The loss of woody debris eliminates habitat for a host of organisms and an important component of the forest floor that contributes to soil development. Trees are damaged as firewood gatherers snap off limbs, creating a human browse line. Large feeder logs in a campfire often remain partially burned. Unless firewood is locally abundant and excess social trails are not a problem, prohibiting campfires (figure 2–13) is a good practice that will reduce impacts over the long term.
- **Requiring Low-Impact Methods for Confining Stock**—Many low-impact alternatives for confining stock eliminate the need to tie stock to trees (except for short periods). Tying stock to trees not only destroys vegetation around the tree, but could expose the tree's roots and girdle the bark, possibly killing the tree. The telltale sign that a tree has met this fate is a doughnut-shaped depression with a standing dead tree or stump in the middle. Appropriate use of highlines, hobbles, pickets, or electric corrals can prevent this problem. Regulations requiring these types of stock containment are in place at several wilderness areas, including the Lake Chelan-Sawtooth Wilderness and Alpine Lakes Wilderness in Washington.

Figure 2–13—Campfires may leave scars that are difficult to erase.

- **Limiting Campsite Occupancy**—Some areas, such as the Mt. Hood Wilderness, regulate the number of tents or people allowed for a given campsite. This practice prevents a large group from spilling onto vegetated areas. Nor can a small group claim a large campsite that is better suited for a large group. Displacement to other nearby camping areas could become an issue as groups seek a site for a party of their size.
- **Prohibiting Cutting Switchbacks or Leaving the Trail**—Switchback cutting leads to contin-

ued erosion and loss of leaf litter and limbs that often are used to disguise switchback cuts. A special order can be written to make it illegal to cut switchbacks. Rangers in some areas with fragile soils or vegetation, such as Paradise Meadows at Mt. Rainier National Park, cite visitors who leave the trail. With many thousands of visitors, this is the only way to stabilize human-caused impacts to the meadow.

- **Modifying Timing of Use**—Several methods can be used to regulate timing of use without instituting a permit system. The first method is to prohibit certain uses (such as overnight use or grazing) when the potential for impact is the highest. This may be early in the season, when vegetation is just emerging, or it may be at another time to accommodate seasonal wildlife habitat needs. A fee could be charged during the sensitive time period to discourage use. Another way to discourage use could be to gate a road and prohibit vehicle access during the sensitive time period.
- **Redesigning Infrastructure To Stabilize Impacts and Concentrate Use**—With the possible exception of constructed trails or administrative sites, most impacts at wilderness destinations are caused by the ordinary wear and tear of public use. User trails, often called social trails, generally connect various amenities that visitors are seeking. Such amenities might include campsites, viewpoints, access to water for drinking or fishing, firewood sources, and private places for toileting.

Such a network of trails often looks like the spokes of a wheel, or a spider's web. Users often establish many more trails than are really needed (figure 2–14). Trails shift, depending on snow conditions, wet areas, rockfall, or fallen logs. In addition, trails often shift onto vulnerable locations, such as along the fall line of the slope, which is subject to erosion, or onto areas with fragile vegetation.

Figure 2–14—Multiple trails established by visitors can cause more damage than one carefully located trail. A maze of trails going every which way is a common problem in recreation areas.

Most campsites are on relatively flat areas near water. The earliest users (in some cases, indigenous peoples) wanted the best view, which means that many scenic areas have large, denuded, and sometimes eroding campsites. When these sites are occupied, other users may have difficulties reaching the shoreline or campsites nearby.

Good project planning will take into account a variety of criteria that might include:

- Leaving the necessary infrastructure of social trails and improving them if needed
- Closing unneeded social trails
- Closing excess campsites, while leaving enough campsites to meet demand
- Stabilizing or closing eroding trails or campsites
- Closing or reducing the size of trails or campsites that do not meet visual objectives
- Closing campsites that are visible from other campsites
- Closing trails or campsites to protect other resource values, such as cultural artifacts, rare plants, or animal habitat
- Installing barriers to delineate trails and campsites
- Hardening trails or campsites as needed to concentrate use

- Providing facilities to concentrate use (figure 2–15), such as toilets or facilities to hold stock.
- Identifying signs that might be needed to inform the public
- Anticipating the likelihood of public acceptance and the range of possible user behaviors when making these determinations

Methods for implementing these criteria will be discussed in more detail in chapter 3.

Figure 2–15—The Wallowa toilet design has been used by the Forest Service since the 1920s. A carefully located toilet helps alleviate recreation impact by reducing the number of social trails, by reducing vegetation disturbance, and by protecting water quality.

2.1.13 Passive Restoration of Damaged Soil and Vegetation

Before concluding that a vegetative restoration treatment is the minimum tool, consider whether natural recovery, or passive restoration, might be successful. Passive restoration allows secondary succession of native plant communities once the conditions preventing vegetative recovery have been abated. Passive restoration has the benefit of allowing Mother Nature to do the healing, producing a more natural result.

Sometimes active restoration may not be necessary once the human impact has been removed. This is especially true in areas:

- That are wet
- That still have live plant material in the soil
- Where the soil is in good condition to serve as a seedbed
- That have a suitable native seed source nearby

The following criteria favoring passive restoration are based on those used by Rocky Mountain National Park (U.S. Department of the Interior National Park Service, Rocky Mountain National Park, 2006):

- The disturbed site will resemble an early-, mid-, or late-seral condition for an undisturbed community growing under similar environmental conditions.
- Adequate native propagules remain in the soil or plants will be able to colonize from nearby sources.
- The disturbed site will preserve natural interactions between individual plants growing on the site and adjacent to the site, including their genetic integrity.
- No exotic plant species that could impede revegetation are on the disturbed site or nearby.
- The site is more than 160 feet (about 50 meters) from a trail, destination area, or campsite.
- Recreation use can be controlled to manage site recovery.
- The site's appearance is not a factor.
- The site has topsoil, natural levels of soil compaction, and soil microbes are still intact.
- The site is stable (no active human-caused soil erosion).
- No other factors are known that might impede natural recovery.

Passive restoration requires managers to accept whatever time scale Mother Nature dictates. For example, the lush forests of the Eastern United States seem to recover rapidly without human intervention. In contrast, most upland Western ecosystems require decades, if not centuries or millennia, to recover. A long timeframe for recovery may be acceptable—give yourself permission to think beyond human time scales. Such long time scales may not be acceptable if resource values would continue to degrade or if social setting objectives cannot be met. Appendix D, *Case Studies*, includes an excellent case study that describes how implemention of a grazing system allowed a meadow on the Dixie National Forest in southern Utah to recover naturally.

Natural Recovery in Rocky Mountain National Park

At Rocky Mountain National Park, a lake shoreline (figure 2–16a) recovered naturally (figure 2–16b) after a dam was breached. The soil was rich with nutrients and still held a large seedbank and pieces of live plant material. The park was able to save the expense of a costly restoration project (Connor 2002).

Rocky Mountain National Park addresses passive restoration in the park's vegetation restoration management plan (U.S. Department of the Interior National Park Service, Rocky Mountain National Park, 2006). A go/no-go checklist (U.S. Department of the Interior National Park Service 2002) ensures that passive restoration is considered when criteria can be met. Otherwise, the checklist helps managers document the need for active restoration.

Figure 2–16a—A lakeshore in Rocky Mountain National Park, CO, before recovery.

Figure 2–16b—The same lakeshore after natural recovery.

2.1.14 Active Restoration of Damaged Soil and Vegetation

Even with volunteer labor and partnerships, restoration projects in wilderness are expensive per square foot of area treated. In addition, restoration is a form of manipulation, although at a very small scale. For example, future researchers will want to know where your restoration sites are so they don't become confused while studying otherwise intact native plant communities.

Restoration becomes the "minimum tool" when less manipulative options would fail to return the area to an acceptable standard. If excessive impacts remain once other options have been implemented, restoration may be part of the solution.

Figure 2–17—Lake Mary, a popular recreation destination in the Alpine Lakes Wilderness, WA.

2.1.15 Adjusting Management Actions: A Tale of Two Lake Basins

The examples of two different lake basins in the Alpine Lakes Wilderness in Washington show how management can be adjusted to bring areas toward their desired condition. The "minimum tool" strategy for each of these locations, developed through trial and error, involved a multipronged approach.

Lake Mary (figure 2–17), a subalpine lake basin, experienced many years of sheep grazing before it became a popular recreation destination. In the 1960s, managers installed picnic tables, a hitch rack, and garbage pits. In the 1980s, a number of management strategies were employed to reduce impacts. These included:

- Prohibiting campfires
- Installing two toilets
- Moving the access trail to a more durable alignment
- Restoring the area by transplanting plants salvaged during the trails project

By then, the area had become wilderness, so all structures other than toilets were removed. Additional wilderness-wide regulations included a limit of 12 combined people and stock in a group, a 200-foot (about 61-meter) setback for stock access, and a regulation making it illegal to enter a closed restoration site.

These strategies were working in part, but the impacted areas, including the areas that had received restoration treatments, were not improving (figure 2–18), according to monitoring data. Factors that prevented the impacted areas from improving included continued erosion and compaction,


Figure 2–18— The worst eyesore at Lake Mary was a large, denuded stock camp near the lake's outlet. Despite previous restoration attempts, continued use of the site deterred recovery. (This view of the camp was created by splicing two photos.)

continued human and stock use in closed sites, and the loss of the organic soil horizons. In 1992, a site assessment was completed. The following year, additional strategies were adopted. They included:

- 200-foot (about 61-meter) stock setback
- Campsite designations to concentrate use
- Delineation of trails and campsites with barriers such as logs or rocks

The restoration work was redone with a much more intensive approach—steep sites were stabilized with check-dams before being backfilled with mineral soil and topsoil carefully gleaned from sources nearby. High school students grew plants from locally collected seed. In addition, the sites were seeded when the seedlings were transplanted. A better erosion-control product was used and oak signs were installed to close restoration sites permanently. At first, a small map was installed to help users locate campsites, because only two sites were visible from the lakeshore.

Fast forward from 1993 to 2002. The revised management strategy is meeting with success. The restoration work is flourishing in most locations. Visitors know where they can walk and camp. The foreground view by the lake is dominated by native vegetation and well-located trails (figure 2–19), instead of a huge, bare-dirt campsite that blocked access to the lake. Visitors say that Lake Mary looks far better now than it did in previous decades.

Now let's contrast the experience at Lake Mary with the experience at the popular Enchantment Lakes Basin. In comparison to the annual precipitation of 81 to 100 inches (2.06 to 2.54 meters) at Lake Mary, the Enchantments receive about 46 to 60 inches (1.17 to 1.53 meters) of precipitation, mostly as snow in winter. Climbing into the Enchantments requires a very steep scramble. As a result, the area has never had stock use or commercial grazing. The area became popular in the 1960s and 70s when hundreds of people camped in the 3-square-mile (7.8-square-kilometer) basin on weekends. Campsites formed on virtually every flat, dry spot. Hundreds of campsite inventories document extensive impacts during that era.

Figure 2–19—Two volunteers and a paid crewleader spent 33 workdays installing barriers and adding locally collected topsoil to this former stock camp at Lake Mary. Native greenhouse-grown seedlings were planted, and locally collected seed was sown across the site. Four years later, most plantings were thriving and seeded species, such as Sitka valerian, were becoming established. Barrier logs defining the trail remained in place. Silt no longer flowed directly into the lake, and a more attractive view greeted visitors to Lake Mary.

By the early 1980s, the vegetative condition had declined to a range rating of "poor" because of human foot traffic alone, despite many aggressive management strategies. Campfires had been prohibited, toilets had been installed, trails had been hardened, and group size had been limited. Local soils are so thin and dry that attempts at restoration succeeded only in the wettest of locations (figure 2–20). Because the lakes had measurable levels of fecal coliform

Figure 2–20—Thin, dry soils in the Enchantment Lakes Basin have scuttled most restoration efforts. (This photograph was digitally altered to remove distracting elements.)

and fecal streptococcus from human and dog feces, vault toilets were installed and dogs were prohibited.

In 1987, a limited entry permit system was implemented to manage a carrying capacity of no more than 60 people overnight at one time. A few years later, the group size was reduced to eight. Education messages (figure 2–21a) were strengthened to coach people on how to walk, camp, and even urinate (the mountain goats paw up vegetation to eat the salt in urine) in a way that protects fragile meadows.

Figure 2–21a—Coauthor Chris Ryan (right) checks a climber's limited entry permit and explains policies designed to reduce visitor impacts at the fragile Enchantment Lakes Basin.

Long-time visitors are beginning to notice an improvement in vegetative condition, which can be attributed to many factors. Trail hardening (figure 2–21b) and cairns marking the trails keep most traffic on a durable route, preventing hikers from creating parallel trails and damaging sensitive shorelines. Well-established campsites can accommodate the reduced use. Prohibiting campfires and providing toilets (figure 2–21c) further limited the development of social trails. This area will always pose management challenges, but the overall trend of wilderness quality is no longer declining. Because of the area's harsh conditions, management actions other than restoration proved more effective in reaching objectives.

Figures 2–21b and 21c—The combination of reducing use, hardening trails (top), installing toilets (bottom), and prohibiting fires has been a more successful strategy than restoration for reducing impacts at the Enchantment Lakes Basin.

2.2 Putting It All Together—Developing a Restoration Plan

Now that your team has considered all the options, it's time to develop a strategy likely to succeed at meeting wilderness goals and standards. In other words, your team determines the minimum tool based on step 2 of the *Minimum Requirements Decision Guide*. If you are completing an environmental assessment to comply with NEPA procedures, you will develop several alternatives (such as a no action alternative, a partial alternative, and a complete restoration alternative)—with each alternative being responsive in some way to the key issues identified during scoping.

The restoration plan includes pertinent wilderness goals from the land management plan or regulatory mandates and incorporates local concerns. The plan describes all the supporting actions to be taken as part of a holistic solution. These actions may include reducing use, furthering information and education programs, or recommending intensive site management techniques. An example of a good restoration plan is included in appendix D, *Case Studies*.

A restoration plan contains site-specific prescriptions for miniprojects that are linked to sites and trails numbered on a map (see figure 2–6). A specific prescription is developed for each miniproject, including the objective of the treatment, stabilization and site preparation treatments, soil treatments, vegetative treatments, and plant protection treatments. The needs for signs also are identified.

A project area map should show the location of specific action items, such as which trails and campsites are to be closed and which are to remain open. Sketch maps help show the design of each miniproject. For instance, a sketch map might show how a campsite could be reconfigured. Photos of each miniproject site (figure 2–22) can be included with the prescription and sketch map. Provide enough detail that a new crewleader could implement the prescription successfully.

Locations of suitable native materials, such as rocks and downed logs, are mentioned in the plan. Note potential sources of local fill material, topsoil, and organic matter. Strategies for rehabilitating borrow areas are addressed.

Figure 2–22—If a site is discontinuous, identify each of the sections to be treated. For example, the area above the trail could be identified as site F–1 and the area below the trail as site F–2.

The restoration plan also addresses the best management practices for protecting wilderness resource concerns. Examples of best management practices include:

- Measures for preventing the introduction of noxious weeds, pests, or diseases
- Protocols for maintaining the genetic integrity and diversity of plant communities when collecting plant materials for the project

Select the best management practices that are responsive to the minimum tool requirement, answering the question, "What operating requirements will minimize impacts?"

Safety concerns also should be engineered into the project. What tools, supplies, personal protective equipment, and work procedures will reduce exposure to illness or accidents? How will the crew communicate if a problem occurs? Consider the logistics of an evacuation, should one be needed. Develop or revise a safety plan and job hazard analysis. Job hazards specific to restoration work include back strain (figure 2–23), knee strain, wrist fatigue, injuries related to walking, and dirt that can get into your eyes. Exposure to environmental factors becomes more prolonged because the work keeps you in one place. Consider the effects of sun, heat, cold, precipitation, and biting insects.

The restoration plan may include cost estimates and potential labor sources. For logistical planning, it is helpful to include specific information, such as the length and width of each miniproject, and estimates of any materials needed; the numbers of checkdams and their sizes, the amount of fill material needed, the estimated number of plants needed (by species), the amount of erosion-control blanket needed, and the number of signs that might be needed. Such detailed estimates will take much of the guesswork out of purchasing supplies, growing plants, and determining whether adequate native materials are available at the project location.

Figure 2–23—Lift with your legs, not with your back! Plan restoration projects with safety in mind.

It is helpful to identify in advance where workers will camp (figure 2–24a), and any supplies they will need. If workers will stay at the area for days or weeks, determine how to arrange for food storage, water treatment and storage, and warm clothing and bedding. Careful planning will prevent further damage to vegetation. It is also important to identify a staging area where tools, supplies, and plant materials can be stored (figure 2–24b). If transplants remain

Figures 2–24a and 24b—Select camping (top) and staging (bottom) areas that can absorb the wear and tear of crew traffic.

in containers for more than a couple of days, they will need to be watered. If the staging area is not near water, you may need to provide water with a gravity feed system, or use another system to provide water.

The restoration plan may consider a phased-in approach, treating the less stable or more highly visible problems first. This is especially important when the project is not fully funded, or when all the work cannot be completed at once.

The restoration plan should include an information plan. Site-specific signs are one means of providing information, but other means may be needed to gain the support and cooperation of area users. The different ways of gaining support and cooperation are considered in more detail in chapter 4.

Training needs can be included in the restoration plan. Restoration training (workshops or on-the-job training) and

A Sample Small-Site Prescription

Site 4 at Cradle Lake will be closed to camping. The main trail (Trail No. 1) to the site will be left open for those circumnavigating the lake. Trail No. 12, a social trail that drops down to the lakeshore, will remain open to provide access to water. The applicable reference plant community is dominated by Idaho fescue (*Festuca idahoensis*), Sitka valerian (*Valeriana sitchensis*), American bistort (*Polygonum bistortoides*), glacier lilies (*Erythronium grandiflorum*), and spring beauty (*Claytonia lanceolata*). Material containing these plant species will be salvaged as plugs from the planned trail relocation (figure 2–25). Seed from these plant species and any others in seed in this same meadow type will be collected and sown when the project is implemented. The site is 1,200 square feet (about 111 square meters), requiring 300 lineal feet (about 91 meters) of an excelsior erosion-control blanket. One oak sign with a post will be needed to close the site.

Figure 2–25— This site at Cradle Lake in the Alpine Lakes Wilderness, WA, was restored using plant material salvaged during a trail relocation project.

certification may be needed before some measures can be implemented. Include training as part of project costs.

The plan needs to include a format for documenting accomplished work and a monitoring plan. Ongoing maintenance requirements also are addressed. Refer to chapter 4, *Restoration Program Development and Support*, for additional suggestions.

Using the NEPA process, you now have a preferred alternative that will be sent out with the additional alternatives for public comment. Or, if your decision falls under the criteria for a categorical exclusion (from further documentation in an environmental assessment), you have formulated your decision (provided, of course, that the decisionmaker approves). Any further analyses, such as biological assessments (sometimes required for compliance with the Endangered Species Act) or cultural resource reports, are finalized. Formal concurrences are obtained from other agencies before the decision document is signed.

2.2.1 Considering the Time Required for Plant Propagation

Restoration projects take at least 3 years (Hanbey 1992). The first year is for completing the site assessment, formulating a restoration plan, reaching a NEPA decision, and for collecting plant material used for propagation. The second year is for implementation of management strategies, including site treatments. The third year is for maintenance of the project, including any watering, signing, and initial adjustments. Each step may take much longer.

Project implementation often takes place over the course of several years or even longer. For example, at Paradise Meadows in Mt. Rainier National Park restoration treatments have been ongoing for decades because of the challenges of managing millions of visitors in a fragile subalpine setting. The maintenance phase extends into the future, because restoration projects are a long-term commitment. Monitoring may continue over many years.

So where does collecting and propagating plant material fit in this schedule? If you have a guarantee of project funding for a multiple-year project, you may hedge your bets and collect plant material as part of the site assessment during the first year. Unfortunately, this puts the cart before the horse—you haven't even determined whether restoration will be included in the preferred alternative.

If you are collecting seed, this is really no big deal; seed is easy to collect for small-scale projects. Refer to section 3.10.8, *Working With Seed,* to learn how to collect and store seed properly. Once funding is secured, you can arrange for plants to be grown from seed, keeping in mind that it takes at least 6 months to produce transplant-sized stock (figure 2–26). Any cuttings you collect will need to be transported to a grower immediately. Some trees and shrubs are best planted as larger stock, which may take several years to grow.

If you are unsure of project funding, collect seed during the planning phase and store it. If the project is funded, deliver the seed to a grower with a goal of planting seedlings during the second year. Collect cuttings during the second

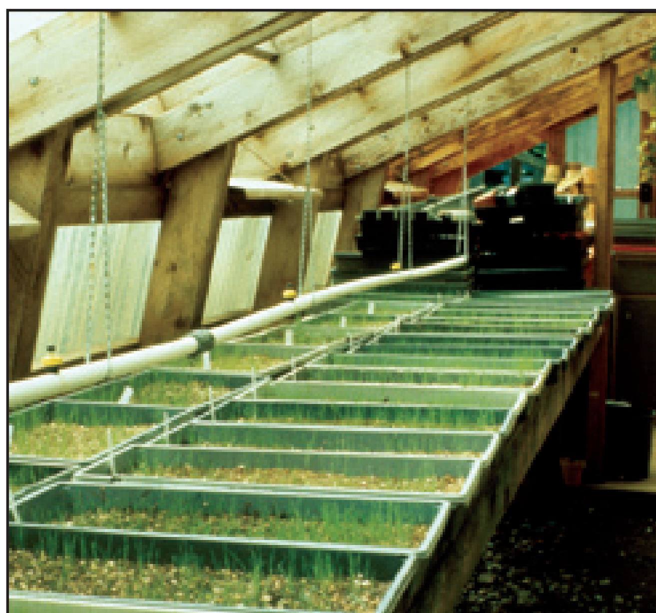

Figure 2–26—Sedges and grasses were planted during the fall in the greenhouse at North Cascades National Park, WA. They were transplanted nearly a year later.

year. During the third year, plants grown from cuttings would be interplanted with seedlings planted during the second year. You could obligate money for the third year's work during the second year with a small contract to cover the cost out of the second year's funds.

Plant storage also requires attention to timing. Your grower may have plants ready before you are able to plant. If so, arrangements must be made for plant care and storage.

2.2.2 Research Opportunities

Early in the planning process, it is worth discussing whether your project might provide opportunities for research. While a large body of research exists on restoration, there is still much to learn, especially with restoration in our remote and fragile wilderness environments.

Including a research element in the project design could change your project. For example, a research design might need to be laid out in defined plots (figure 2–27) that may not meet visual objectives. A certain number of replicates will be needed, requiring treated areas to be as similar as possible. This could require restoration sites to be selected based on research needs rather than recreation management objectives.

Research will require some areas to be marked, at least temporarily. Incorporating research objectives might require additional funding. And finally, because research may require different treatments to be compared, some treatments may fail or be significantly less successful than accepted restoration treatments.

Research projects require further consideration of the minimum requirement and minimum tool process. Can the research take place outside of wilderness? If not, will the knowledge gained by the research further the purposes of wilderness? And, if research will be conducted in wilderness, how can the project be designed to accomplish research objectives while minimizing permanent or temporary impact to the wilderness environment.

Figure 2–27—This restoration research design studied seedling emergence using five different site treatments in 10.76-square-foot (1-square-meter) cells.

Even if you don't incorporate formal research in your project, it is important to experiment with different species, new products, or different techniques on some portion of your project. Be sure to share your findings, so the art and science of restoration will continue to develop.

Example of a Graduate Study

For her graduate research study, Joy Juelson compared a control (no site preparation) to five different site preparation treatments intended to enhance seedling emergence (Juelson 2001). Her research was conducted at the dry Enchantment Lakes Basin in the Alpine Lakes Wilderness in Washington. The area averages 46 to 60 inches (1.17 to 1.53 meters) of precipitation annually, but almost all of the precipitation falls as snow during the winter months; summers are dry with little or no rainfall. Species used in the study included Parry's rush (*Juncus parryi*), black sedge (*Carex nigricans*), and partridgefoot (*Leutkea pectinata*).

Standard treatments that occurred on all plot cells included scarification, inoculation with mycorrhizal fungi, addition of organic material, creation of safe sites for seed, mulching, and weekly watering. Differences in seedling emergence (figure 2–28) were compared for the following treatments:

- Covering the site with polyethylene sheeting (Visqueen) during the germination period.
- Doubling the amount of water given weekly.
- Supplementing all missing soil nutrients.
- Supplementing only magnesium (in the form of Epsom salts) to restore cation (positively charged ion) exchange.
- All treatments combined.

Her findings generated many useful observations:

- Seedlings emerged even as the snow was melting off the sites.
- All treatments supported seedling emergence in dramatic comparison to the control. The Visqueen treatment yielded the most seedlings. The "all treatments combined" treatment yielded the least seedlings.
- During the first season, partridgefoot seedlings were more abundant than those of the other individual species.
- During the second growing season, when the plants were watered less, many of the partridgefoot seedlings died, allowing the sedge and rush to become more dominant.
- During the second season, seedlings at sites with a north to northwest aspect had substantially better survival rates than seedlings at sites with a south to southeast aspect. Plots that initially had the Visqueen treatment fared the best during the second year.

This story had a sad ending. During the third season, watering was delayed until about 3 weeks after the snow had melted. The soil dried out completely and all the tiny seedlings perished. Retaining soil moisture is a major limiting factor to restoration success in the Enchantment Lakes Basin.

Figure 2–28—Counting seedlings requires attention to detail.

2.2.3 Identifying Research Needs

What are the limiting factors to successful restoration in your environment? What are the potential detrimental effects of restoration? The following suggestions may generate additional research questions (Rochefort 1990, Juelson 2001). Also refer to appendix A, *Treatments To Manage Factors Limiting Restoration*, as a source of ideas for research or experimentation.

- **Water Limitations**—Many plantings fail because of seasonally dry conditions. Regular watering programs usually are not feasible and cost effective on remote sites. Experimentation with techniques to improve water availability (figure 2–29) for plants would be a worthwhile research endeavor.
- **Soil Treatments**—Research is needed to determine which techniques can be used to restore native soil characteristics, benefiting vegetative recovery. Treatments might address problems caused by compaction or missing organic layers and consider whether soil amendments and reestablishment of soil organisms would help solve such problems.
- **Plant Genetic Diversity**—Research is needed to identify the genetic characteristics of plant species used for restoration. This research will be used to determine scientifically the proper distances for gathering plant materials when treating a restoration site.

Figure 2–29—Coauthors David Cole (far left) and Vic Claassen (far right) assess water availability on a dry site with wilderness rangers T.J. Broom (in Forest Service jacket) and Gabe Snider.

- **Plant Propagation**—Research is needed to determine how to propagate species that lack propagation protocols or that are difficult to propagate.
- **Species Introductions**—Restoration projects risk introducing organisms that are not indigenous to the local area. When a site is treated, little is known about the presence of such organisms and whether they will survive in the wild. Such organisms could be in imported soil, soil amendments, or plant materials. Examples of such organisms include soil or plant pathogens, soil micro-organisms, plant seeds, plant or fungal spores, and insects.

2.3 Concluding Thoughts

Good restoration planning takes time. Your team will want to be clear on what needs fixing, why it is broken, and the best methods for repair. Your aim should be to design an integrated sustainable solution that is compatible with management objectives. Adjustments can be made over time as results are monitored.

Chapter 3