

3.10.2a Using the Reference Sites To Develop Plant Prescriptions

The vegetative characteristics of the reference site should be compared to those of your restoration site. Attributes to compare include the species represented, their relative abundance, distribution patterns, and age classes. Observe the stand structure; note the mix and spatial distribution of trees, shrubs, grasses, forbs, lichens, and mosses (figure 3–97). Note the growth forms of the various species present, paying special attention to species that appear to spread underground or establish freely from seed. If the site being treated is not homogenous, observe the relationship between changes in vegetative characteristics and subtle changes in site characteristics, such as full sun versus partial shade, or changes in slope or aspect. If the reference site itself has been disturbed and revegetated, examine how the successional transition occurred.



Figure 3–97—Learn to recognize vegetative patterns that form separate plant communities. Even within a meadow, the vegetation type will change based on factors such as slope, aspect, soil depth, and soil moisture. This meadow is in the San Juan National Forest, CO.

The plant communities found on your reference sites serve as a pharmacopeia, from which you can select appropriate plant species for restoration. Conceptually, the process goes like this: you want to replace the dominant species found on your disturbed-but-revegetated reference site and introduce at least some of the dominant species found on your undisturbed reference site. Those dominant species may be problematic for restoration because of limiting factors or challenges in working with the plants themselves. In that case, you will identify the early- to mid-seral species that lend themselves to propagation and outplanting, even if they are not dominant. You also will think about how to restore the stand structure so that the site supports an appropriate mix of growth forms and mimics a natural appearance, while addressing any additional limiting factors and design concerns.

The following four steps will help you translate the plant community found on the reference site into a vegetative prescription for your restoration site.

1. **Investigate the feasibility of propagating dominant species found on the disturbed-but-revegetated reference sites**—There are a couple of ways to identify dominant species. Look at species dominance on the reference sites you have chosen—which species are represented in the greatest numbers? Also look at the plant association type—a vegetative classification scheme that categorizes dominant overstory and understory species. These two methods serve as a check-and-balance system for species selection. The reference site will show you which plants are really there, but the plant association type will help you see the site in terms of the broader landscape.

Some dominant species may pose challenges for propagation and restoration. While it is worthwhile to include propagation of these species in your prescription, you may not be able to rely on their reestablishment. In general,

upland shrub species are more challenging to reestablish than graminoids (grasses, sedges, and rushes) and forbs.

2. Investigate the feasibility of propagating early- to mid-seral species found on the disturbed-but-revegetated reference site—

The theory of vegetative succession is that early-seral species (lichens, mosses, graminoids, and some herbaceous plants) develop site conditions allowing mid-seral species (herbaceous species and some shrubs) to invade, which further develop site conditions allowing late-seral species (some shrub species and trees) to invade. This is a grossly oversimplified textbook example of Type I Succession (Smith 1980). In reality, your project environment could have trees or shrubs that behave as early-successional species. For instance, bitterbrush (*Purshia tridentata*), a shrub, can establish itself on loose, bare soils. Your reference site has been chosen because, after considering soil conditions and other limiting factors, you gauged that you could reestablish this vegetative condition on your restoration site. If you can't count on reestablishing some of the dominant species, you will want to identify appropriate early- and mid-seral species to add to the mix.

A botanist or ecologist can help you identify successional patterns at your site. Identify the plants that fall into the early-, mid-, and late-seral stages of succession. For some plants, this may be general knowledge; if not, examine the project area to distinguish between disturbed sites with early-seral plant communities growing on exposed mineral soil, mid-seral communities growing where there is some soil development, and late-seral communities (often comprised of trees or shrubs). Look for species that grow both on disturbed and undisturbed

sites; a number of practitioners have observed that mid-seral species hold promise for restoration, because they survive into the development of late-seral communities (Belnap and Furman 1997; Chambers and others 1984; Chapin 1992). Grasses and sedges generally colonize disturbed soils, as do plants that spread from stolons or runners (figures 3–98a, 98b, 98c, and 98d).



Figure 3–98a—Plants that spread underground often can be spotted by their trailing habit (plants may be in clumps or even in a line). Such plants are early-seral to mid-seral species that make good restoration candidates and may be resistant to trampling. Such species include bunchberry (*Cornus canadensis*).



Figure 3–98b—False lily-of-the-valley (*Maianthemum dilatatum*), a good candidate for restoration projects.



Figure 3-98c—Twinflower (*Linnaea borealis*), a good candidate for restoration projects.



Figure 3-98d—Five-leaved bramble (*Rubus pedatus*), a good candidate for restoration projects.

3. Investigate the feasibility of propagating dominant species on the reference site, especially mid-seral species—As described in chapter 1, theories of how plant succession takes place differ. One theory, Type III Succession, presumes that once a vegetative stand becomes established, it will hold its own against “all comers” (Smith 1980), unless the stand is disturbed. If we presume this theory applies to your reference plant community, and your long-term goal represents a late-successional

community, it would be prudent to introduce some of the species of your long-term goal, favoring mid-seral species that help develop conditions that might eventually support late-seral species.

4. Identify the growth forms desired as an outcome of restoration (trees, shrubs, forbs, graminoids)—While the graminoids and forbs are relatively easy to reestablish, they may not provide the stand structure represented in your reference sites. If your long-term goal is to have a mix of species providing ground cover, shrubs, and trees, identify the species that will move you toward this goal. It may be necessary to propagate shrubs from cuttings if seed is not readily available. For example, in the subalpine tree clumps of the North Cascades, currants (*Ribes*) are well established in the dense shade of undisturbed reference sites. The currants rarely set fruit, making it necessary to consider propagating them from cuttings.

3.10.2b Additional Limiting Factors and Design Considerations

Plants also must be selected in light of other ongoing problems such as trampling, recompaction, or continuing erosion. It is important to identify these potential factors and predict the factors that will represent the most difficult problems. Refer to appendix A, *Treatments To Manage Factors Limiting Restoration*, for additional advice on selecting plant species to help address your project’s constraints. This appendix lists specific plant types and propagation methods used to address a number of extreme conditions that make it difficult to reestablish vegetation.

The nature of the disturbance may vary within the project area, requiring you to vary the species used for restoration. For example, the cut roadbeds may support different species than the fill slopes because of the differ-

ences in soil depth. In arid environments, grasses have deeper root systems than shrubs; a grassland that loses soil may support nothing but shrubs in the future (Belnap and Furman 1997).

Addressing Trampling in a Vegetative Prescription

Examining current human uses may further define limits to restoration and guide the selection of certain plant materials and propagation methods. Would continued human use of the project location prevent recovery of the desired plant community? Activities to consider might include walking, camping, off-highway-vehicle use, commercial grazing, or recreational use of packstock. Decide which of these activities will be removed through the project design, and which

will be compensated for by selecting certain plant materials or types of treatments.

In areas with continued recreation or livestock use, it may be important to select plants that can withstand trampling.

Addressing Visual Concerns

Selected plants need to be harmonious with landscape patterns and features. For example, trees or shrubs may be selected to hide a landscape feature, such as a gully.

Addressing Erosion Control

Plants also may be selected for their ability to help control erosion. A mix of growth forms provides more erosion control. The two main types of roots are taproots and fibrous roots. Taprooted plants (such as carrots and dandelions) have a large central root with finer lateral (side) roots. Taproots act like an anchor to stabilize soils. Taproots also help break up soil compaction and provide a means for water to percolate deeper into the soil. Plants with fibrous roots (such as grasses) spread a mass of fine roots that stabilize the surface of the soil better than taproots. The two types of roots can complement each other. Trees and shrubs are more deeply rooted than grasses and herbaceous species. A combination of all these growth forms can help stabilize eroding sites.

Plants that root or become established quickly also help stabilize erosion. Refer to table 3–8 in section 3.4.9, *Bioengineering Applications*, for a list of riparian species that root readily where soil moisture is abundant. These species can be used to build living structures to stabilize riparian sites. These techniques were described in more detail in section 3.4.9a, *Selecting and Installing Bioengineered Structures*.

In environments where native plants become established slowly, such as the subarctic, sometimes a sterile hybrid plant, such as rye, is used to provide roots that will stabilize the surface (Densmore and Vander Meer 1998). The use of sterile hybrids and other nonnative cultivars was discussed more fully in section 3.10.1d, *Nonnative Plants, Agronomic Varieties, or Native Cultivars*.

Characteristics of Plants That Can Withstand Some Trampling (Hingston 1982)

Plants that can withstand trampling generally:

- Are low-growing rather than erect
- Are tufted
- Are armed with thorns, prickles, or spines
- Have leaves in a cluster at the base of the stem (basal rosette)
- Have stems that are flexible rather than brittle or rigid
- Have small, thick leaves
- Can grow from the base of the plant as well as the tips of the stems
- Have flexible leaves that can fold under pressure
- Are perennials that can regrow from buds beneath the soil's surface where they are protected from trampling
- Can reproduce vegetatively from suckers, stolons, rhizomes, or coring, as well as sexually through seeding
- Grow rapidly
- Can reproduce despite trampling

Adding Nitrogen-Fixing Plants, If Appropriate

Many restoration projects benefit from the use of native nitrogen-fixing plants (figure 3–99). These plants have a symbiotic relationship with bacteria that convert atmospheric nitrogen into a form that can be used by plants. The bacteria live in easily observed nodules found on the roots of the host plant. Nitrogen fixation is common in many species in the pea family (Fabaceae), as well as some other species. If plants that fix nitrogen are in the project area, they are likely to be included in the mix for propagation. If so, it will be necessary to inoculate the disturbed soil with bacteria (see section 3.2.5c, *Soil Bacteria*).



Figure 3–99—Plants in the pea family (such as this lupine growing in subalpine meadows in the Cascades, above) cohabit with *Rhizobium*, a bacteria that lives in root nodules (below). The *Rhizobium* bacteria convert atmospheric nitrogen into a form plants can use, improving soil fertility.

Genera That Include Some Nitrogen-Fixing Species (Barbour and others 1987; Hingston 1982)

- *Alnus*
- *Casuarina*
- *Ceanothus* (figure 3–100)
- *Cercocarpus*
- *Colletia*
- *Comptonia*
- *Coriaria*
- *Discaria*
- *Dryas*
- *Eleagnus*
- *Hippophae*
- *Luetkea*
- *Myrica*
- *Purshia*
- *Rubus*
- *Shepherdia*



Ceanothus prostratus

Figure 3–100—Many species of *ceanothus*, found throughout the drier regions of the Western United States, fix atmospheric nitrogen. Mahala mat (*Ceanothus prostratus*), which has striking blue flowers, ranges from the Sierras and western Nevada north to southern Washington. Drawings courtesy of the University of Washington Press (Hitchcock and Cronquist 1976).

3.10.3 Determining Propagation Methods for Your Site and Species

The costs and success rates of different methods of propagation vary dramatically. Helpful information can be found in a variety of sources. The USDA Natural Resources

Conservation Service has developed a comprehensive national plants database that is on the Web at <http://plants.usda.gov/>. Additional helpful Web sites are listed in chapter 5. The propagation requirements of many species can be found in the scientific literature and in books on propagating native plants. Some recommended references include:

- *Growing California Native Plants* (Schmidt 1980)
- *Propagation of Pacific Northwest Native Plants* (Rose and others 1998)
- *Seeds of Woody Plants in North America* (Young and Young 1992)
- *Native Plant Propagation Techniques for National Parks* (Link 1993)
- *A Native Hawaiian Garden: How to Grow and Care for Island Plants* (Culliney and Koebele 1999)
- *Grass, Grass-like, Forb, Legume, and Woody Species for the Intermountain West* (Ogle and others 2003)

Subject-area experts often are happy to share what they have learned; seek the advice of other restorationists, native plant growers, or the technical support staff at the USDA Natural Resources Conservation Service Plant Material Centers.

Appendix A, *Treatments To Manage Factors Limiting Restoration*, lists a variety of potential treatments, including plant types and propagation methods. Appendix B, *Propagation and Establishment Requirements for Selected Plant Species*, contains species-specific information on propagation methods and plant establishment. The next section describes in more detail the field techniques for onsite propagation and for collecting plant materials for offsite propagation.

If successful, onsite seeding with local native plants is the least expensive method of propagation and tends to do the best job of providing genetic diversity. In many environments, including arid lands and in the subalpine zone, onsite seeding has not been very successful. Transplanting wildlings (wild plants removed from one area and transplanted to another) or other methods of onsite vegetative propagation can be fairly economical, especially if volunteer labor is

available. However, these methods tend to harm the collection areas. Projects that disturb areas nearby may provide an opportunity to transplant materials. Not all species transplant well. Large plants and taprooted plants are especially challenging to transplant.

3.10.3a Seed-Increase Programs

Offsite propagation methods, such as seed-increase programs (also called a grow-out) or nursery-grown planting stock, are more expensive than seeding with local native plants or transplanting. In many cases, offsite propagation is the only viable option. Seed-increase programs are useful if a large amount of seed is needed. A relatively small amount of seed (such as several pounds or a kilogram or two) is grown as a seed crop on a relatively small plot (for instance, 1 acre or 0.4 hectare) by a farmer or nursery (figure 3–101). This approach is especially useful when planning for rehabilitation of roads, slope stabilization following wildland fires, and so on.

Seed-increase programs require 2 to 5 years to produce an adequate seed crop. Typically, the seed from the first crop is sown to produce a larger second crop, increasing the volume of seed. The cost of the seed produced goes down each year, but each successive crop runs an increased risk of genetic shift, because the growing conditions will favor plants that respond well to agriculture.



Figure 3–101—If a large quantity of seed is needed for restoration, consider a seed-increase program. A relatively small amount of seed is grown in an agricultural setting, such as at the Forest Service’s J. Herbert Stone Nursery in Central Point, OR, and harvested to provide more seed.

Genetic shift can be minimized by mimicking natural growing conditions as closely as possible and by having successive harvests of ripe seed. The USDA Forest Service's Pacific Northwest Region has a native plants program that is using seed-increase programs on a number of forests.

3.10.3b Propagation Methods and Stock Types

For nursery-grown plants, it is important to identify the propagation method and stock type. Propagation methods commonly in use for native plant production include growing from seed, various types of cuttings, divisions, layering, or tissue propagation.

The stock type is a combination of the length of time a plant is grown in a nursery before being outplanted and the method of growth (bareroot or different sizes of containers). Outplanting is when a plant is taken from the nursery to be planted elsewhere. Determining the appropriate stock type by species is a very important step in the planning phase. For each species, the appropriate stock type will depend on the project goals as well as known or inferred information on species propagation success and plant establishment once stock has been outplanted (refer to appendix B, *Propagation and Establishment Requirements for Selected Plant Species*, for species-specific information).

Consult with professional growers or other practitioners to help determine the best stock type. In some cases, selecting several stock types may enable the practitioner to hedge against losses or to provide an array of plant sizes mimicking the natural condition at the project location. The stock types are listed below in relative order of expense (Potash and Aubry 1997):

1–0 Ship: A bareroot seedling grown for one growing season in a nursery bed. Many species perform well in outplanting, including many riparian species and shrubs. Most species are started from seed, although some can be grown from cuttings.

Plug: A containerized seedling typically grown for one growing season. Outplanting performance is similar to 1–0 ship. Seedlings can be propagated from seed or cuttings.

Cuttings are much more expensive. The containers come in many sizes, depending on the size of seedling that is needed. Generally, the bigger the container size, the better the seedling will perform. This stock type is good for rocky soils where it is difficult to excavate a hole for a large root system. Because the plant is in a rooting medium, there is more flexibility in the timing of outplanting than with bareroot stock.

2–0: A bareroot seedling grown for two growing seasons in a nursery bed, producing a bigger seedling than 1–0 ship or plug stock types. A conifer seedling grown as a 2–0 generally does better than plug and 1–0 ship seedlings on harsh, dry sites.

1–1: A bareroot seedling that is transplanted to a nursery growing bed after one growing season. It is grown for a second year and then lifted as a bareroot plant for outplanting. Generally, these seedlings have a thick stem and a very massive, fibrous root system. On highly productive sites, these seedlings grow very quickly, staying above competing vegetation. Because of their exceptional growth potential, they often are used in hot, dry areas or in areas where animals damage seedlings.

Plug–1: A bareroot seedling grown as a plug the first season and then transplanted to a nursery bed for another year. The performance and uses of a plug–1 seedling are similar to those of a 1–1 seedling.

2–1: A bareroot seedling grown for two seasons in a nursery bed and transplanted into a nursery bed for another year. This stock type can be used for species that are very slow growing. For faster growing species, the shoot-to-root ratio can be high, which means that the root system may not support the shoot, causing poor performance when the seedlings are outplanted.

3–0: A bareroot seedling grown for three seasons in a nursery bed. This stock type is used for slow-growing species.

Large containers: A seedling that usually is grown for more than one growing season in a 1- to 4-gallon (3.8- to 15-liter) or larger pot. Because of their large size, seedlings of this stock type appear established when planted and can

withstand some of the abuses that are common in heavily used recreational sites.

Container Sizes

In the wet forests of western Washington, plants destined for restoration in wilderness are generally propagated in 2-inch (50-millimeter) pots (figure 3–102). Plants that need more than one growing season before being outplanted may be transferred to larger pots.



Figure 3–102—Wilderness restorationist Greg Shannon transfers sedge seedlings started in flats to 2-inch (50-millimeter) pots where they will grow for 3 more months before planting. The 2-inch (50-millimeter) pots provide a plug that is large enough to be planted in areas with dependable precipitation.

For drier sites, long planting tubes such as the 8-inch (200-millimeter) or longer super cell, will make it possible to outplant seedlings with a deeper root system. Most native plant nurseries use this approach (figure 3–103).



Figure 3–103—Methow Natives (Winthrop, WA) and many other native plant nurseries use long tubes for growing plant stock with deeper root systems. This approach works well when establishing plants on drier sites and in areas where irrigation is a problem.

The restoration staff at Joshua Tree National Park in California uses a 36-inch (914-millimeter) “tall” pot and an 18-inch (457-millimeter) “half tall” made from 8-inch- (200-millimeter-) diameter PVC pipe with a removable mesh bottom (figures 3–104a and 104b). Creosote bushes or other shrubs grown in these pots for 6 months or so can be transplanted easily into machine-augered planting holes. Their root systems are deep enough to reach the available soil moisture. Plants grown in large containers such as these are the most expensive, but sometimes stock from large containers is the minimum tool necessary to assure outplanting success.



Figures 3–104a and 104b—To establish native vegetation on the exceedingly dry Mojave Desert, the staff at Joshua Tree National Park, CA, developed 36-inch (914-millimeter) “tall” containers and 18-inch (457-millimeter) “half tall” (top). The mesh bottom is removed before the containers are planted (bottom). The container is removed by lifting it from the planting hole.

3.10.3c Noxious Weeds and Other Nonnative Invaders

Unfortunately, noxious weeds have thoroughly invaded some remote backcountry and wilderness areas. You could unknowingly identify a weedy species (figure 3–105) as having potential for revegetation. The botanist on your team will help you avoid this mistake. Weedy species have great potential—that’s why they’re a problem.



Chrysanthemum leucanthemum

Figure 3–105—Although oxeye daisy (*Chrysanthemum leucanthemum*) is prolific and easily established (even pretty), you wouldn’t want to inadvertently select this noxious weed to restore your restoration site. One of the authors has been pulling oxeye daisy seedlings in her garden for 15 years and still hasn’t depleted the seedbank. Drawings courtesy of the University of Washington Press (Hitchcock and Cronquist 1976).

3.10.4 Concluding Thoughts on Plant Selection

Selecting plant species involves careful consideration of project goals, site capability, and methods to ameliorate adverse conditions. Very few projects fully succeed in replacing all elements of the predisturbance plant community—its species composition, structure, and function. It is easy to become discouraged, because deep down we all recognize the importance and desirability of restoring the predisturbance community. A careful planning process, such as the one described in this chapter, will help you make the best call possible, given site conditions, technological capabilities, and the project budget.

3.10.5 A Comparison of Propagation Methods

Growing plants from seed is the only form of propagation that results in sexual reproduction with a wide array of genotypes represented in the propagated plants. The vegetative forms of propagation produce clones of the donor plant, limiting the genetic diversity of the restored plant community. However, some species are not easy to grow from seed. In such cases, vegetative propagation techniques become the solution for providing adequate and affordable plant materials. Tables 3–11 and 3–12 summarize the pros and cons of various onsite and offsite propagation methods.

Table 3–11—The advantages and disadvantages of different onsite propagation methods.

Onsite propagation method	Advantages	Disadvantages
Common to all methods of onsite propagation.	All methods, if successful, are less expensive than offsite propagation and generally eliminate the time required to propagate plants.	Plant materials for propagation often are limited. Success can be limited in many environments.
Onsite seeding—Native seeds are collected and sown directly onto the area to be restored.	If successful, this method is relatively inexpensive. For small areas, onsite seeding can be accomplished without special equipment. Most seeds would not require special treatment to break dormancy. Treatment can be done without delay while plants are growing in a nursery. The genetic diversity of the plant community is maintained.	Germination rates are low in many environments, such as in arid lands and in the subalpine zone. Seeds sown on arid lands could be dormant for years before rainfall is adequate to induce germination. Seed production and viability can vary tremendously from year to year. Seed may have to be collected several years in advance. It can take many years for seedling plants to mature and establish stand structures similar to the target plant community. Rodents, birds, or insects can eat the seeds.

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Table 3–11 continued

Onsite propagation method	Advantages	Disadvantages
<p>Onsite rooting of cuttings—A limited number of species will root when the cuttings are planted directly in moist soil on the area to be restored.</p>	<p>If successful, this method is relatively inexpensive.</p> <p>Treatment can be done without the delay of growing plants in a nursery.</p> <p>Onsite rooting of cuttings works well with bioengineering methods of slope stabilization.</p> <p>Larger plants are more visible at the restoration site and could deter use.</p>	<p>This technique requires that the soil be moist long enough for the seedling to develop an adequate root system; generally limited to riparian areas.</p> <p>Success is limited to genera and species that root readily, such as willow (<i>Salix</i> spp.), some dogwoods (<i>Cornus</i> spp.), cottonwood and poplar (<i>Populus</i> spp.), some alder (<i>Alnus</i> spp.), some elderberry (<i>Sambucus</i> spp.), and honeysuckle (<i>Lonicera</i> spp.).</p> <p>Plant material for cuttings may be limited.</p> <p>New plants are a clone of the parent plant, limiting genetic diversity.</p> <p>This technique is more labor intensive than seeding.</p>
<p>Onsite divisions—Species with fibrous root systems, rhizomes, or stolons can be dug up, broken apart at the roots into multiple plants, and transplanted. <i>Sprigging</i> is a variation where small plant parts are scattered across the site and raked or tilled into the soil without planting each part individually.</p>	<p>If successful, this method is relatively inexpensive.</p> <p>Treatment can be done without the delay of growing plants in a nursery.</p>	<p>Plant material to be broken apart may be limited.</p> <p>New plants are a clone of the parent plant, limiting diversity.</p> <p>Onsite divisions require more labor than seeding.</p> <p>Onsite divisions can damage undisturbed areas where material is collected. Holes need to be filled after transplants are dug up.</p>
<p>Onsite layering—The attached branch or shoot of a parent plant is rooted.</p>	<p>Works well on trails that have shrubs growing alongside the trail.</p>	<p>Success is limited to species that layer or root readily.</p> <p>Onsite layering generally is useful only where appropriate shrubs, trees, or vines are growing alongside the site being treated.</p> <p>The new plants are a clone of the parent plant, limiting diversity.</p>
<p>Transplanting wildlings—Native local plants are dug up and transplanted.</p>	<p>Ground-disturbing projects that are occurring nearby, such as trail or road construction, can be a source of transplants.</p> <p>Local plants are adapted to the area.</p> <p>This technique produces results immediately with more mature plants. Larger plants are more visible at restoration site and could help deter use while the site is recovering.</p>	<p>Not all wildlings will transplant well, especially large plants, plants with taproots, or plants with very specific requirements for establishment.</p> <p>Unless transplants are salvaged, transplanting damages the undisturbed area where the transplants are collected.</p> <p>Salvage operations often require holding plant materials until they can be replanted. This increases the labor required and can complicate the logistics.</p>

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Table 3-12—The advantages and disadvantages of different offsite propagation methods.

Offsite propagation method	Advantages	Disadvantages
<p>Common to all methods of offsite propagation. Nursery stock types range from bareroot plants, to small containers or plugs, and to larger containers. The preferred stock type is based on predicted survival requirements and project goals.</p>	<p>For many environments, offsite propagation allows for much more rapid stabilization of the site and establishment of plants at the site.</p> <p>Offsite propagation is the best way to propagate plants that are difficult to establish with onsite techniques.</p> <p>Offsite propagation prevents damage to the collection site caused by overcollection of materials that are needed for most onsite propagation techniques.</p>	<p>All offsite propagation techniques require varying amounts of facilities, equipment, staff expertise, and daily care, raising costs considerably above those for onsite treatments. The time needed to propagate species may range from 6 months to several years.</p> <p>Pathogens or other nonnative insect or plant species may be introduced.</p> <p>Transportation of plants to roadless project locations increases the cost and adds logistical difficulties.</p> <p>Plants may need to be held at the nursery until they can be outplanted. This increases logistical difficulties and the possibility that plants may not survive.</p> <p>Animals are most likely to eat fertilized nursery-grown stock once it's outplanted.</p>
<p>Offsite seedlings—Native seeds are collected and sown into nursery beds, flats, or containers.</p>	<p>Offsite propagation can produce better germination and survival rates than onsite seeding.</p> <p>The diversity of the plant community is generally maintained.</p>	<p>Seed production and viability can vary tremendously from year to year. It may be necessary to collect seed several years in advance.</p> <p>Offsite germination and growing conditions may select for or against certain traits, changing the genetics of propagated plants.</p>
<p>Offsite rooting of cuttings—A portion of the plant, usually the stem, is cut off and rooted. Different species respond to different types of cuttings.</p>	<p>Offsite rooting of cuttings is a good method when seed is unavailable or difficult to work with.</p> <p>A wide variety of species will root from cuttings.</p> <p>Many species grow faster from cuttings.</p>	<p>New plants are a clone of the parent plant, limiting diversity.</p>
<p>Offsite divisions—Species with fibrous root systems, rhizomes, or stolons can be dug up, broken apart at the roots into multiple plants, and then transplanted.</p>	<p>Offsite divisions is a good method when seed is unavailable or difficult to work with.</p> <p>Divisions can be made over and over in a nursery until it is time to outplant the seedlings.</p>	<p>The new plant is a clone of the parent plant, limiting diversity.</p>

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Table 3–12 continued

Offsite propagation method	Advantages	Disadvantages
Seed-increase programs—Native seed is collected onsite and grown offsite to produce a seed crop.	<p>Seed-increase programs are the only way to multiply a small amount of seed into a large amount. This technique is best used when a large quantity of seed is needed.</p> <p>Seed can be used as soon as it is produced, or stored until it is needed for fire rehabilitation or mine reclamation.</p>	<p>The plant’s genetic makeup can shift based on growing conditions, harvest timing and methods, and seed-cleaning techniques.</p> <p>It is difficult not to introduce weed seed.</p>
Tissue propagation—Plants are propagated from very small pieces of plant material, such as the growing tips of shoots.	Tissue propagation is generally used with species that are difficult to propagate or with rare plants with limited vegetative material available for propagation.	<p>This technique is very expensive.</p> <p>New plants are a clone of the parent plant, limiting diversity.</p>

Project planning should include consultation with others having experience with the same species or in similar environments. Even slight changes in environmental conditions can change the outcome of a treatment.

If plants are propagated offsite, they will need to be slowly hardened off before outplanting. Hardening off is the process of weaning plants off the optimal growing conditions provided in the nursery so they will survive once they are planted in the wild. Hardening off usually involves reducing water and shade, increasing or decreasing ambient temperatures, and reducing fertilization. Many species are top pruned or even root pruned several weeks before outplanting to increase the root-to-shoot ratio. The hardening-off process usually occurs at the nursery, although sometimes restorationists are required to take care of this crucial step themselves (figure 3–106). In some cases, the plants are hardened off at the restoration site.

Bareroot stock is hardened off to induce dormancy. Plants are held in a cool, dark, moist environment until they are transplanted. If USDA Forest Service tree coolers are available, they are ideal for storing bareroot stock.

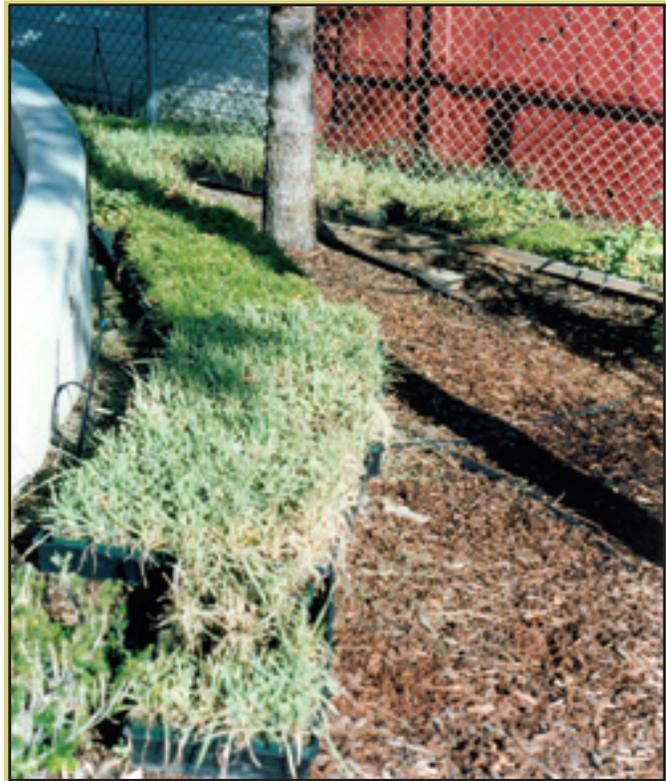


Figure 3–106—Before plants used in restoration are outplanted, they are hardened off, gradually increasing their exposure to the conditions they will experience after they have been planted in the wild. As can be seen on these sunlit sedge flats, their foliage was cut back to increase the root-to-shoot ratio, increasing the chance that they would survive. These plants were stored behind the Leavenworth Ranger Station in Washington for 3 months before outplanting.

3.10.6 Plant Collection Principles

The genetic principles for collecting plant material outlined earlier in this guide should be followed, including adhering to local or agency genetic policies. In the absence of such a policy, the following guidelines are conservative enough to preserve the genetic integrity of plants in wilderness or other wildland project locations, while assuring adequate representation of an array of genotypes to establish a genetically diverse population.

Plant materials, such as seed, cuttings, or wildlings should be collected from throughout the entire plant collection zone, taking equal amounts from at least 30 to 50 unrelated individuals (figure 3–107). The plant collection zone can extend 250 vertical feet (about 76 meters) above and below the project location. Start collections at the upper elevation limit to assure that some of cold-adapted individuals are included. Ideally, in wilderness, plant material should come from the same subbasin. If plant material is scarce, collecting plant material within the same watershed is considered acceptable.



Figure 3–107—Wilderness restorationist Greg Shannon collects cuttings from heather for propagation. All cuttings taken from an individual plant will be a clone of that plant, making it important not to collect too many cuttings from one plant.

Propagules should be collected from plants that differ in appearance and are found in different microhabitats, if possible (rather than only from the most robust-looking

individuals on the most ideal sites). Parent plants that are diseased or that have insect infestations should be avoided. If the site to be treated is unusually harsh, seek out propagules from plants found on sites that are just as harsh. To avoid genetic bias, avoid overharvesting stands that are unusually lush.

Nursery propagation methods are not described in detail in this guide. Many books and publications on propagation techniques and the propagation of native plants are listed in the references. The interest and commitment to using native plants is rising within agencies, which means that restorationists are more likely to have professional support to help them select propagation methods and develop sources of locally adapted native species.

If plants are going to be propagated offsite, consult with the grower. Questions to ask the grower include how to collect and prepare plant material, how much to collect, and how to ship the material to avoid injuring it. In addition, the plants may need to be stored or held over until the next growing season before outplanting. For an additional cost, some growers can do so. Others may not wish to.

If nursery-grown stock is to be inoculated with soil organisms, the plant collector will probably collect inoculum at the same time that the plant materials are collected.

3.10.7 Preventing Further Damage to the Project Area

Once the planting begins, take care to avoid further damage to the project location, including the freshly prepared site and the vegetation surrounding it. Have a plan in place for work crews to follow, including how crews will travel in and around the work site. Select a staging area, preferably one that has already been impacted, or one in a resilient location. If the work crew is to camp, select a campsite that can withstand the impact of their stay. If the area receives recreational use, the campsite should be isolated from public view. Crews should be taught low-impact practices before they begin their work.

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Once the planting bed has been prepared, minimize soil compaction caused by foot traffic or machinery. It often helps to identify a travel corridor in the site being treated, perhaps even laying out stepping stones. Indoor-outdoor carpet, scrim, or worn out foam sleeping pads, make good walkways to protect meadow vegetation from excess trampling. Ladders have been used to access steep, eroding banks to avoid walking up and down the slope.

Additional Information on Plant Propagation

For additional information on plant propagation, consult *Plant Propagation: Principles and Practices* (Hartmann and others 1990) and *Plant Propagation* (Browse 1979).

3.10.8 Working With Seed

Seed crops can vary widely from year to year, with some species going for years with no seed or fruit (in which case a different propagation method may need to be chosen). Because of this variation, it may be necessary to collect and store seed for several years to have an adequate supply for a restoration project.

3.10.8a Seed Collection

The seed of many plant species ripens and drops quickly. With some species, it is not uncommon to leave the project area for a few days and come back to find that all the seed has completely dropped. If seed collection is important, the ripening seed must be monitored carefully. Characteristics to look for include: capsules beginning to open, pods beginning to darken, seed that is swelling and becoming hard instead of pulpy when squeezed, seed that drops from the plant when disturbed, grass heads that are beginning to cure, fleshy fruits that are ripening, and so forth (figures 3–108a and 108b).

Some fruits explode to disperse seeds. These fruits should be harvested when the pod is nearly ripe, before the pod explodes. Pods or capsules can be stored in paper bags so seeds will not be lost when the capsules explode. Collect cones when they have turned from green to brown, but before they have opened.



Figures 3–108a and 108b—Partridgefoot seed (top) is collected by District Ranger Becki Heath, a dedicated wilderness line officer (bottom). Partridgefoot (*Leutkea pectinata*) seed is easy to collect by leaning the stems into the opening of a bag and tapping the stems gently. Seed is ripe when the flower stalks begin to turn reddish brown and the capsules open.

Seed collection should occur throughout the ripening period, to assure genetic diversity. With some species, collection can begin during the latter part of the “soft dough” stage, which can be recognized by squeezing the seed between the thumb and forefinger and squeezing out the contents. In the “hard dough” stage, the seed cannot be squeezed open and is generally too hard to bite open.

The ripening period for a particular species may not be consistent from year to year. In mountainous environments, the initiation of flowering often is based on temperature, which can vary from one year to another, sometimes delaying flowering for weeks. Seed will mature earlier or later depending on the initiation of flowering. In desert environments, flowering often follows rain, with seed production close behind.

Do not deplete an area of more than 50 percent of its seed. This generally is not a problem, because most collectors drop seed when collecting it or don’t harvest entire stands. Be careful not to contaminate native seed by inadvertently collecting weed seed. Seed collected throughout the plant collection zone at a given site or sites can be combined by species into a seed lot (figure 3–109).



Figure 3–109—Seed collected throughout the plant collection zone at a given site or sites can be combined by species. This combination is a seed lot that will be documented on a seed collection form.

Most projects in wilderness areas and remote sites are relatively small, allowing seed to be collected by hand. A number of simple comb-like tools can be fabricated to make the collection go faster. For small collections, collectors can use small paper bags to hold the seed. For larger collections, collectors can wear fruit picking bags, carry plastic pails, carry metal trays like baking pans, or use similar devices. It is rarely feasible to use machinery when harvesting native seed from the wild (Young and Young 1986).

The following techniques have proven successful for harvesting seed by hand:

Cutting—Use scissors or a sickle to remove seed heads. When using a sickle, gather the stems with seed heads in one hand, and cut the stems as close below the heads as possible. Wear leather gloves to protect your hands. This technique works well with herbaceous plants and grasses.

Stripping—To strip seed, pinch fingers and pull them over the seed head, allowing the seed to drop into a container. This approach works with graminoids, forbs, and some shrubs when the seed is ready to fall from the plant. Gloves will protect your fingers.

Beating and Shaking—Plant stems can be held and shaken over a tray or tarp or beaten by hand or with a paddle. For large collections, tarps are less efficient because of the time needed to spread them out. It is faster to hold a metal tray under the branch or stem.

Pruning—When other methods are not successful, seed can be removed from tall shrubs or trees by pruning limbs bearing seed.

3.10.8b Initial Processing of Seed

Seed will mold and rot quickly if it is not cured properly. Collectors should spread the seed out to dry for about a month in a warm (not hot) location. Seed that is small will dry in less time. Small quantities of seed can remain in brown paper bags while drying. The mass of seed should be pushed to the edges of the bag to maximize air circulation. If seed is cured outdoors, it must be protected from animals that eat seed and from excess heat, precipitation, and frost.

Dry cones by spreading them out in a single layer on racks in a warm place with good air circulation. Turn the cones every few days to prevent them from molding. Cones will open in a few weeks or so (Sound Native Plants 1994).

Seed processing and cleaning is a rather involved science. Professional growers use a wide array of equipment to separate the seed from the plant material and to clean the seed. Professional growers can help, particularly with seed that is difficult to clean, but their services add to the cost. For many species, field practitioners can do part or all of the cleaning themselves, being careful to retain as much of the viable seed as possible to preserve genetic diversity.

Seed processing and cleaning needs to be more thorough if seedlings are to be grown in a nursery or resown with machinery. But even if the seeds will be sown onsite, excess plant matter mixed in with the seed can cause the seed to deteriorate and increase the time needed for the seed to break dormancy. For instance, the awns on the seed of some species of grass have a chemical inhibitor that maintains seed dormancy.

3.10.8c Hand-Processing Seed

Rub the plant parts to free the seed from its covering. The plant material can be rubbed on a wire screen (figure 3–110) or between blocks of wood or bricks. Plant material can be put inside a bag or a rubber tire tube and kneaded under-



Figure 3–110—Plant material can be rubbed on a wire screen to remove the seed.

foot to abrade it. One restorationist suggests placing a bag with seed and several pairs of shoes in a dryer and tumbling them with no heat. You may want to be careful whose dryer you pick for this method!

Chaff can be separated from heavier seed by blowing the seed with a fan while it is being rolled down a screen or poured between two containers. An alternative method is to put plant parts in a tub and run a string-type weed eater in the tub to separate the plant materials from the seed. Most seed will work its way to the bottom of the tub.

Seeds can be extracted from fleshy fruits by crushing the fruit on a screen with a rolling pin, or by running it through a fruit press (figure 3–111). An alternative method is to macerate the fruit by adding about 50 percent water by volume and running the material through a blender that has its blades taped to reduce damage to the seed. The blender's blade can be replaced with strips of rubber, which will reduce the seed that is damaged. Allow the resulting slurry to sit until the pulp has separated from the seed; this may take a few minutes to a few days. Fleshy fruits that have dried out can be run through a grain mill with a coarse setting.



Figure 3–111—Seed can be extracted from fleshy fruits by crushing the fruit on a screen, by macerating the fruit with water in a blender, or by running dried fruit through a grain mill with a coarse setting. This photo shows black twinberry (*Lonicera involucrata*).

Some seed, such as those from cones, pods, or open seed heads, can be placed in bags and trod underfoot. Tree nurseries have more thorough methods for removing seed from cones. Any wings on the seed need to be removed before the seed is sown.

The seed of most species requires a period of afterripening, ranging from one to several months when the embryo matures inside the seed. With some species, afterripening takes place inside the fruit. This adaptation prevents seed from germinating prematurely during inhospitable growing conditions, such as during the winter or the extreme heat of summer.

If plants are to be grown professionally, seed should be shipped as soon as it has been cured to prevent seed mortality. Ship early in the work week to avoid weekend delays.

3.10.8d Seed Storage

Practitioners may choose to store small quantities of seed, particularly if the seed will be used for onsite seeding. Seed can be destroyed by insects, fungi, or ice crystals during storage. For most seed, proper drying coupled with storage in a cold, dry environment will maximize seed viability (figure 3–112).



Figure 3–112—Once seed has been air dried thoroughly, the greenhouse staff at Joshua Tree National Park, CA, stores seed lots in a freezer.

Young and Young (1986) suggest that moisture and temperature influence seed deterioration in the following way; first, each 1-percent reduction in seed moisture doubles the life of the seeds, and secondly, each 10-degree-Fahrenheit (6-degree-Celsius) reduction in seed temperature doubles the life of the seeds. If stored seed has more than 14-percent water content, ice crystals can form and destroy the embryo. Water content of less than 5 percent also seems to damage the seed.

If mold or insects are anticipated to be a problem, the surface of the seed can be sterilized with a 10-minute soak in a solution of two parts bleach to three parts water, or of 3-percent hydrogen peroxide. Follow the soaking with a thorough rinse in water. These treatments are toxic to some plant species and should be used only if they are needed (Bainbridge and others 1995). A sprinkling of diatomaceous earth also will protect stored seed from damage by insects.

The maximum temperature for drying seed is 90 to 100 degrees Fahrenheit (32 to 38 degrees Celsius). Seed must be dried in an area with low relative humidity, because the idea is to draw moisture out of the seed rather than into it. Seed needs to be dried quickly, but if it is dried too rapidly, the surface of the seed can be damaged by cracking.

Small lots of seed are stored at below freezing temperatures in sealed jars, such as canning jars. Indicator desiccants, such as colored silica packets, should be placed in each jar to absorb moisture. When the silica changes color, it is replaced with a new packet. The old packet can be renewed by heating it in an oven to drive off the moisture.

For larger seed lots, seed can be stored in moisture-proof containers, such as metal boxes with a gasket on the lid. Properly dried seeds can keep for several years when stored this way. Professional seed-processing facilities have moisture-proof storage rooms with storage conditions that are close to ideal.

3.10.8e Seed Testing

Pure live seed per pound is a measure of viability and purity, determined by a seed testing lab. Most wilderness projects probably don't need to test seed viability. Testing

may not be necessary for species that have reliable seed viability. Without high-quality seed, all the time, money, and effort of preparing a site could be wasted. If professional or commercial services are involved in collecting seed, seed-increase programs, or growing seed offsite, the percentage of pure live seed should be determined. Knowing the pure live seed per pound also is important if seed mixes are being developed.

Pure live seed per pound is determined by sending about 500 seeds of a species to a seed lab for testing. Several methods are used to determine viability. Tetrazolium staining, used to determine whether the dormant seed embryo is respiring (still alive), is one of the more reliable tests for larger seeds. Tetrazolium staining also has the benefit of offering quick results for seeds that might need longer to break dormancy. Tetrazolium staining generally is not feasible with small seed (the size of grains of salt or sand). Instead, a weighted replicate germination test is used (Vankus 2004).

Each State has a seed testing program geared toward supporting the agricultural industry. Not all seed labs are equally proficient in testing native seed (Vankus 1997). To identify a reliable lab, consult with native growers or large-scale restoration practitioners.

3.10.8f Breaking Dormancy

Most seeds have adaptations that allow them to remain dormant until growing conditions are favorable for seedlings to become established. Seed dormancy can be caused by a thick seed coat, chemical inhibitors, or a combination of both. Breaking dormancy is critical to professional nurseries, which know a great deal about the requirements of many species. The practitioner needs to be aware of these basic concepts, especially in regard to preparing seed and timing onsite seeding. The methods for breaking dormancy for a number of selected species are identified in appendix B, *Propagation and Establishment Requirements for Selected Plant Species*.

In nature, plants with thick seed coats often are broken down when birds crack the seed or partially digest it. Seed

may be abraded when wind tumbles it across rocks or when it is scorched by fire. If seed with a thick seed coat is sown without pretreatment, germination rates will be lower and germination will take longer.

Scarification is used to break dormancy in plants with thick seed coats. Depending on the species, the seed coat can be cracked with a rolling pin, clipped with snips, nicked with a knife, abraded with sandpaper between blocks of wood, soaked in hot water or sulfuric acid, or leached in running water (figures 3–113a, 113b, and 113c). Care must be taken to avoid damaging the tiny embryo. Sulfuric acid treatment should be done professionally, because the acid is dangerous, timing is critical, and a neutralizer is needed. Seed can be leached in water by putting seed in a cloth or mesh bag and allowing water to run through the seed lot for the correct period of time, often 48 hours. An easy way to run water through the seed lot is to put the bag of seeds inside the tank of a toilet that is used frequently.



Figure 3–113a—The seed of creosote bush (*Larrea tridentata*) needs to be leached with water to wash away chemical inhibitors stored in its thick seed coat. (Hickman 1993).



Figure 3–113b—Creosote seed is laid on wet, paper-lined trays to germinate. Germinants are carefully picked up with tweezers and planted in pots at Joshua Tree National Park, CA. (Hickman 1993).



Figure 3–113c—Did you know that creosote bush is one of the world’s oldest living plants? Some creosote bush clones are 10,000 years old (Hickman 1993).

Plants with chemical inhibitors that maintain dormancy usually require cold-moist stratification. In nature, this usually happens during the fall and winter, when soil temperatures are consistently cool and moist soil is against the seed. For the practitioner planning to sow seed onsite, a fall sowing provides the best chance that the seed will break dormancy over the winter, although during some years the conditions may not allow the seed to do so. The period of

time needed to break dormancy varies tremendously by species.

Professional growers induce cold-moist stratification by packing seed in a moist medium, such as peat moss, and storing the seed in a refrigerator for a set period of time. Or seed can be soaked in a net bag, which is placed inside a plastic bag and hung inside a cooler.

After dormancy has been broken, the seed begins to germinate. To germinate, a seed must imbibe water, which induces chemical changes that allow metabolism to increase. When the embryo grows, it pushes the seed open and begins to root in the soil, a process called seedling emergence if the tiny plants survive germination. Germination requirements, which include the amount of moisture, warmth or cold, and darkness or light, vary by species. The germination requirements of a particular species will influence the practitioner’s choice of cultural methods.

Additional Information on Seed Collection, Processing and Storage

Two good references are *Collecting, Processing, and Germinating Seeds of Wildland Plants* (Young and Young 1986) and *Native Seed Collection Guide for Ecosystem Restoration* (Huber and Brooks 1993)

3.10.8g Onsite Seeding Techniques

Onsite seeding is a common restoration treatment. Seeding success varies, depending on the environment, weather conditions, species, and the degree of site disturbance. If successful, direct seeding is the least expensive method of restoring native vegetation and it assures genetic diversity.

Species generally respond most favorably if the seed is covered with soil, increasing the moisture available to

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support the emerging seedling. Seed can be broadcast on the soil surface and covered with soil, or seed can be placed directly into the soil. Most subarctic species require light for germination, an exception to the rule of covering seed with soil.

Projects in wilderness or at remote sites probably will be seeded by hand sowing (figure 3–114) or with a hand-held seed spreader, such as a Cyclone seed spreader. Larger projects outside wilderness can use equipment to broadcast seed quickly. Helicopters can broadcast seed over huge landscapes. They work well on steep or broken terrain. Machines called drillers drill small holes to a specified depth in the ground, drop in seed, and tamp the ground, producing uniform rows of seedlings. Hydroseeding mixes seed with

water and sprays the mixture over the area to be treated. Hydroseeding can be very effective in temperate areas, but is not very successful on arid lands. It also requires motorized equipment, making it unsuitable in wilderness areas. Other types of equipment, such as centrifugal broadcasters (also called end-gate seeders), cast the seed 20 to 40 feet (6 to 12 meters) and use a harrow or a chain pulled behind the seeder to cover the seed with soil.

Some benefits achieved with machinery also can be emulated on small sites by using handtools. For example, imprinting creates microbasins across the surface of the site that catch water, retain mulch, and provide some protection from wind. Pitting creates even smaller pits about 20 inches (510 millimeters) apart and 2 to 3 inches (51 to 76 millimeters) deep with seed planted inside each pit (Belnap and Furman 1997).

Literature relating to mine reclamation, road obliteration, and other landscape-scale restoration applications describe the use of mechanized techniques for seeding. They will not be discussed further in this guide.

Once seed has been sown on the seedbed, you can lightly rake it into the soil or work it in with your fingertips. A thin layer of topsoil or compost can be added. If the soil is loose, the ground can be tamped lightly to make sure that seed contacts the soil. In sandy soil, seed needs to be planted a little deeper. A general rule of thumb is to plant seed one and a half to two times deeper than the seed diameter. For many environments, mulch will provide additional protection to emerging seedlings discussed fully in section 3.12, *Plant Protection and Establishment*. Some species require a mineral soil seedbed for establishment; practitioners at Denali National Park in Alaska have found this to be true with subarctic species (Densmore and Vander Meer 1998).

If animals are likely to eat too much of the seed, a variety of techniques can be considered to address the problem. In the Southwest, ants are major collectors of seeds. Cracked wheat can be spread before seeding to satiate the ant population (Bainbridge and others 1995). Raking seed into the soil or covering the soil with mulch will help discourage birds and rodents.



Figure 3–114—A Parmesan cheese shaker will help assure that small seed is distributed evenly. If you add the seed to fine, dry sand and put the mixture in the shaker, the seed will go farther than if you spread it with your fingers.

Raising the Soil Temperature To Induce Germination at Subalpine Sites

Seed is sown onto a prepared seedbed in the fall and mulched with an erosion-control blanket (figures 3–115a and 115b). When the snow has melted the following season, clear plastic sheeting is anchored over the seeded area.

Visqueen (polyethylene sheeting) warms the soil and retains moisture, which is especially helpful when working with sedges (*Carex* spp.).

The sheeting is removed before the soil gets warm enough to kill the tiny seedlings. According to backcountry district ranger and restorationist Bill Lester, the technique of using Visqueen to enhance seedling emergence was discovered by accident in North Cascades National Park, WA. When a crew left the backcountry for their days off, they accidentally left a piece of Visqueen lying over some bare soil. When they returned, they noticed that the soil under the sheeting was covered with tiny green seedlings.

The optimal soil temperature is 85 degrees Fahrenheit (30 degrees Celsius). A soil thermometer is used to monitor soil temperature. Frequent monitoring is necessary to prevent the temperature from getting too high or the bed must be irrigated as the soil dries. Perforated landscape plastic has the advantage of ventilating heat better, which could reduce the frequency of monitoring. The sheeting is removed once seedlings emerge, or it could remain longer if temperatures remain cool (Weisberg 1993).

This is basically the same setup that is used in solarization to kill weed seeds (described previously in the soils section). The difference is in that soil temperature is maintained at about 85 degrees Fahrenheit (30 degrees Celsius), the optimal temperature for seedling emergence. Solarization allows soil temperatures to reach temperatures of 180 degrees Fahrenheit (82 degrees Celsius), which kills most germinating plants (Bainbridge 1990).



Figures 3–115a and 115b—Warmth and moisture benefits newly seeded sedges (top). Jute netting (blue strips, bottom) helps protect seeded areas at a restoration site in North Cascades National Park, WA. Drawings courtesy of the University of Washington Press (Hitchcock and Cronquist 1976).