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GERALD MARKS

Revegetation Guidelines for Western Montana Considering Invasive Weeds
Revegetation Guidelines for Western Montana: Considering Invasive Weeds

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Preface

Major portions of western Montana’s landscape become degraded and disturbed every day. As various winds inspire wind-swept areas and displace desired vegetation towards monocultural stands, these areas become further degraded year by year. Diminishing can be natural, such as floods and fires, or artificially human-induced, such as road and construction sites, utility tree trenches and long-term improper grazing. Eventually, some of these disturbances may naturally recover, but it may be many years before desired plants become established.

Conversely, these areas may never naturally recover where invasive weeds establish first, preventing the ability of native plants to establish, grow and mix. Furthmore, these weeds have the potential to spread into adjacent healthy landscapes where local biodiversity is threatened, aquatic and water cycling is altered, wildlife and livestock forage is diminished and soil erosion and stream sedimentation are increased.

Natural re-vegetation can be slow. Artificial re-vegetation of degraded or disturbed areas can speed or secure recovery and mitigate or prevent soil erosion. Re-vegetation can also work to prevent weed invasion and re-establishment. Re-vegetation should only occur when necessary, as determined by the abundance of desired plants and propagules at the site. Re-vegetation is useful in cases where targeted improvement is desired. This publication provides an in-depth, step-by-step guide to the processes and procedures of establishing desired species in most vegetation circumstances in western Montana, west of the Continental Divide. Detailed information for every situation is beyond the scope of this publication; experts and specialists should be consulted as necessary, especially on large or particularly challenging re-vegetation projects.

The author’s objective is to help improve vegetation recovery by providing practical and effective re-vegetation concepts and methods to establish a desired plant community or retain sites to conditions as similar as practicable to the pre-degraded, pre-disturbed state. Depending on your situation, this process can entail many steps: selecting resources, protecting key plant-community components, preparing the site appropriately, reducing weed interference, designing a proper seed mix, seeding using the most effective method. Establishment should be monitored to identify problems that could prevent or interfere with successful re-vegetation. Following establishment, proper vegetation management that favors the desired species will be necessary. This includes long-term maintenance of the desired plant community and detecting future establishment and growth of invasive weeds.

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Step I
Make a Goal Statement

Historically, pest management has evolved for cropping systems and has focused on controlling pests. Today, many land managers focus on weed management simply on controlling weeds, with limited regard to the existing or evolving plant community. On grazed land, forestland and rangelands, the effectiveness of varieties of weed management strategies depends on how land is used and managed. Invasive weeds must be considered in establishing revegetation goals. This implies that just killing weeds is an inadequate objective, especially for large-scale infestations. A generalized objective for ecologically-based weed management is to develop and maintain a healthy plant community that is relatively invasion-resistant while meeting such other land use objectives as forage production or wildlife habitat development or recreation land maintenance (Shade et al. 1996).

A healthy, weed-resistant plant community comprises a diverse group of species that maximize niche occupation. A diverse community captures a large proportion of the resources in the system, which preempts their utilization by weeds. Plant communities with representatives from various functional groups also optimize ecosystem functions and processes that regulate plant community stability. Ecologically based weed management programs must focus on establishing and maintaining desired functional plant communities.

Thus, development and adoption of management strategies promoting desirable species offers the highest likelihood of sustainable weed management. For instance, consider enhancing the functional diversity of plant communities, especially the native forb component. Petcharn (2002) demonstrated that native forbs compete better with spotted knapweed (Centaurea maculosa) than grasses since native forbs and non-native invasive forbs (e.g., spotted knapweed) are in the same functionally similar plant group. Maintaining native forb functional groups such as shallow- and deep-rooted forbs for ecosystem maintenance and invasion resistance could be a primary objective of land managers. Such ecologic knowledge is important in formulating goal statements that direct the establishment of desired plant communities for sustainable land management.

Goal statements describe the desired conditions to be developed. For instance, the goal statement of the Missouri County Weed Management Plan (draft 2002) is to "minimize..."
the impact of noxious weeds through the use of sound ecological practices." Revegetation goal statements might include the following:

- Improve rangeland forage production or rehabilitate degraded or disturbed sites
- Quickly reestablish vegetation to minimize erosion
- Establish species that can minimize noxious weed invasion or reestablishment; and/or
- Restore a healthy plant community.
Step 2
Determine the necessity of revegetation.

Revegetation should only be implemented when necessary. Included are cases where overland improvement is desired to accommodate seasonal forage requirements and in cases where quick groundcover is needed to minimize or preclude erosion. Re-hand planting is also necessary in cases where desired plants and plant species are inadequate at the site to meet various land use objectives, such as to minimize toxic weed invasion and establish or restore healthy plant communities.

Range and improvement/forage production

Profitable ranching includes many components specific to the management of land, livestock, and resources. A year-round forage plan that satisfies livestock needs and maintains forage resources is essential. Often this includes seasonal pasture that can supply nutritious forage at times during the year when other resources are inadequate or unavailable. Revegetating to meet this need and improve range lands is often necessary.

Evaporation control

Revegetation is necessary to reduce the impact of excessive evaporation and speed natural recovery. Planned disturbance activities involving bare slopes often require revegetation in combination with mulch, tilling or erosion control blankets for wind and water protection and to assist germination and establishment. Since prior to a planned disturbance, many projects require a vapor or vegetation subside operation where topsoil containing plant propagules or whole plant and blocks of native soil are removed, set aside, and replaced. Wildlife affected areas also may require revegetation to guard against erosion in special cases involving high severity burns, stream corridor and slopes above 15 percent (see "Revegetating After Wildfires," overhead).

Desired plant introduction

Wind-infested areas with inadequate desired plant canopy cover (figure 1, p. 7), usually less than 30 percent, typically require revegetation with competitive plants to meet various land management goals. (See figure 1 for way to determine canopy cover.) On these sites, weed control is often short-lived because desired species are not available to occupy niches opened by weed control (James 1992, Shley et al. 1990).
Revegetation after wildfire

Revegetation is recommended in some burned area as a result of wildfire. Contact your local Extension or USDA NRCS Resource Conservation Service or Conservation District office to schedule a site visit and an assessment of reforestation needs, which is usually performed through a seed survey. Revegetation only when necessary will avoid suppressing the natural native plant community and conserve limited resources.

Revegetation following wildfire depends on many factors. Among them are these:

- Burn severity: A high severity fire can permanently damage desired plants and seedlings, greatly reducing natural recovery potential.
- Rainfall increase on slopes due to hydrophobic (water-repellent) soils and lack of vegetation which allows rain to run off instead of infiltrate. Lack of competitive plants favors various weed invasions and aggressive reestablishment.
- Revegetation is sometimes recommended for high, burned severity areas, especially when slopes are steep or erosion is a serious threat.
- Shading: Bossing on slopes above 20 percent usually requires quick protection with seedling programs (Zalewski modified) or small grain/forage mixtures. In places where fire killed grasses or forage, an organo-mineral mix will benefit from cross-slope log erosion barriers or common grass mixtures where hydrophobic soils occur. Such forage windows as one does important work in further stabilizing soils.

- Possibility to desiccate: Revegetate channels to mitigate serious erosion, timing increased flows and to flood sedimentation from runoff. The quick temporary cover and productivity, annual plants at 15 pounds per acre or small grains at 20 pounds per acre are frequently seeded within 56 feet of drainage channels, regardless of burn severity. Failing temporary check structures on ephemeral drainages is not beneficial.

- Protect non-porous weed cover: Sods with inadequate desired plant cover prior to the burn as a result of native weed displacement should be considered for reseeding regardless of burn severity (Goodwin and Shirley 2001). Such inadequate cover may be between 20 and 50 percent, the higher percentage by consequence of additional burn-site disturbances such as increased weeds, which favors invasive weed colonization. Revegetation will typically be necessary given an increase to high weed cover coupled with lack of competitive plants and such fire-produced disturbances as increased nutrients and high light conditions.

- Tapped cut. Such areas as new roads, firebreaks and embankments, including cut-and-fill slopes, should be revegetated. During wildfire rehabilitation, consider replanting soil that was pushed aside during firebreak development. By replacing this topsoil, reseeding may not be necessary. For the soil will likely contain an adequate amount of plant propagules. Replace this topsoil as soon as possible and with a minimal number of machine passes.

- Post-fire-grown, non-pretending methods such as annual ryegrass or barley (Hordeum secalinum) and weeds (Pennisetum clandestinum), varieties are often seeded as cover crops with, perennial grains in wildfire-affected areas. The cover crops establish quickly to prevent soil and young, slow-establishing perennial grains. Planting cover crops is beneficial in speeding natural recovery and ultimately providing stable to suppress non-porous weed invasion and growth.

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Introducing and establishing competitive grasses, and eventually forbs, will be essential for successful long-term management of weed infestations and the restoration of desired plant communities (Shelley et al. 2001). Weed density should be significantly reduced to reduce weed interference on seeded species. This may require effective infestation management for the first couple of years or longer, to weed an infestation and significantly reduce competition for light, water, and nutrient resources to benefit desired species. In all cases of weed management, strongly consider protecting and enhancing the growth and vigor of native forbs through careful spot treatment of herbicides or hand-pulling weeds, if appropriate. Unnecessary broadcast herbicide treatments will injure or permanently damage a remnant or remaining native forb component. If entirely removed, this critical-forb component could be impossibly difficult and expensive to reestablish. Furthermore, an intact native forb community seems to be vital to long-term weed management success because forbs may compete with invasive weeds better than grasses do, and provide better plant community invasion resistance (Puryear 2002).

With good weed management, weed-infested sites with more than 20 percent desired vegetation canopy cover do not usually require revegetation. In such cases, adequate desired plants are present to direct natural revegetation. Desired grasses and forbs readily occupy open niches made available by removed weeds.

To determine the general canopy cover of a site:

1.) Obtain a hoop made from coated cable up to 3/4 inch thick (available at most farm and ranch supply outlets) Purchase 95 inches of cable and fasten the ends with a cable ferrule, clamped with a chisel or heavy screwdriver and hammer.

2.) Randomly toss the hoop and let it land flat on the ground.

3.) Visually estimate the percentage of ground covered by the canopy, as shown above, of desired vs. non-desired plants. (Do not count plants—this will give you density.)

4.) Repeat, randomly tossing the hoop throughout the site and visually estimating the canopy cover of desired vs. non-desired plants, at least ten times.

5.) Add the desired plant percentages and divide by 10—or by the number of times the hoop was tossed—to determine the average desired plant canopy cover.
Again, the importance of protecting native forbs cannot be overstated. To avoid injury to this key ecosystem component, weeds should be removed through careful spot treatment with herbicides or by hand-pulling.

Use this chart to determine whether revegetation is likely to succeed based on soil properties without the addition of amendments:

<table>
<thead>
<tr>
<th>Soil parameter</th>
<th>Ideal condition</th>
<th>Acceptable range</th>
<th>My soil properties</th>
<th>My soil: Yes or No</th>
<th>(Are your soil's properties within the acceptable range?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density (g/ml)</td>
<td>1.4</td>
<td>1.2 - 1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil texture (sand, silt, clay)</td>
<td>Loose</td>
<td>Clay loam to sandy loam</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salinity – electrical conductivity (mm ho/eq soluble salts)</td>
<td>0 - 2</td>
<td>&lt; 8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic matter (% in soil)</td>
<td>&gt; 3</td>
<td>&lt; 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.5 - 7.5</td>
<td>5.5 - 6.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium adsorption ratio</td>
<td>&lt; 0</td>
<td>&lt; 1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Revegetation Guidelines for Western Montana
Step 3
Determine the likelihood of successful revegetation

It is important to determine if revegetation is likely to succeed or fail prior to implementation. Many common soil properties can provide a good indication of the likelihood of successful revegetation. In some cases, problematic soil properties can be amended. For instance, highly acidic or highly alkaline soils can be amended with sulfur, peat, lime, or fertilizers. But a practical alternative to amending these soils could be to seed such sites with species adapted to these extremes. Soils with low organic matter can be amended with the addition of compost.

The decision index on the opposite page provides an initial assessment of soil properties found in most NRCS county soil surveys. Soil testing, although usually not necessary, also provides more accurate and site-specific information. (See Step 7, Site Characteristics, p. 40, for additional information on soil properties and successful revegetation.)

Determine the likelihood of successful revegetation

Contact your county or reservation Extension office, weed coordinator, or local NRCS office if your soil properties are outside the acceptable range. Proceed with Step 4 if your soil properties are acceptable.
Step 4
Salvage vegetation and topsoil prior to planned disturbances

Consider preserving or salvaging the vegetation that was on the site before the onset of the disturbance. If it is known in advance that a project will disturb an area and require revegetation, salvaging or taking steps to preserve existing plants and seeds that are already adapted to the site is recommended to avoid permanently losing this resource and to supplement the revegetation process (see Step 11, Transplanting, p. 55). For instance, blocks of the existing native sod can be removed and set aside and replaced after the work has been completed. The addition of such mining major functional groups as forbs should be considered as appropriate to revegetation goals.

As an alternative to salvaging whole plants, some seed companies offer on-site hand collection and custom grow-outs.

Hand collectors gather seed from plants on the site and provide them back to the project as requested. For large or long-duration projects, the collected material can be farmed for a steady supply in subsequent years. Special efforts should be made to decrease negative influences on native forbs on the site.

In addition to salvaging vegetation, also consider salvaging healthy topsoil. And in wildfire cases, plan on replacing soil that was pushed aside for firebreak development. Found in the upper six to 12 inches of the soil profile, topsoil contains microorganisms (bacteria, fungi, protozoa, etc.), earthworms and insects. Topsoil also contains living, pre-adapted plant propagules such as seeds, plant fragments, and whole plants—valuable revegetation resources. Biological activity in this zone cycles soil nutrients and increases nutrient availability, aerates the soil, maintains soil structure and increases soil water-holding capacity. Replication of healthy topsoil enhances revegetation success and promotes establishment of a persistent vegetative cover. Topsoil that is damaged or unfit (e.g., containing high noxious weed cover) should not be salvaged; instead, it should be removed and replaced with healthy topsoil.

Avoid damaging topsoil by keeping the soil alive, noxious weed-free and protected until it can be returned to the site. Salvage topsoil during full operation and while it's moist (not wet) to avoid depressing seedling recruitment. Store it in shallow piles less than two feet high, exposing as much soil to air as possible.
possible (to avoid anesthetic conditions that can damage microorganisms) and for as brief a period as possible. A study in Yellowstone National Park showed that topsoil stripped and replaced within 90 days retained viable populations of mycorrhizal fungi, but topsoil stored over a winter lost most of its mycorrhizal propagules (Williams 1991). Rokich et al. (2000) found that stockpiling topsoil for one or three years demonstrated substantial, significant declines in seedling recruitment—to 54 percent and 34 percent of the recruitment achieved in fresh topsoil, respectively. If you must store topsoil longer than a few weeks, cover it with a protective, sterile cover crop such as Rgenum or tricolata, sterile hybrid cross between common wheat and tall wheatgrass (Trisetum aestivum × Elyrigia elongata) and common wheat and crested wheatgrass (T. aestivum × Secale cereale), respectively. Most of the stored topsoil often and evolve nonsensical words.

When replacing topsoil in a site, do so with a minimum number of machine passes. To avoid weed invasion or soil erosion, schedule topsoil replacement when there is an assurance that the area will be revegetated within a few days. If the volume of topsoil is limited, consider concentrating the returned topsoil in small pockets to allow increased retention of the biological activity of the soil (Chinn and Zedzki 1993). However, if you have enough topsoil, spread it at least an inch deep. Rokitch et al. (1997) found that a thin layer of topsoil spread so

Salvage vegetation and topsoil prior to planned disturbances.
Seedbed preparation

The necessity of seedbed preparation depends on the seeding method (See Step 9, “Determine a Seeding Method,” p. 49), influenced by site accessibility and terrain and seedbed characteristics. Seedbed preparation is usually not necessary when drill seeding, but is strongly recommended when broadcast seeding or hay-mulch seeding. Generally, the ideal seedbed is firm enough so that the seed will be in contact with the soil and the soil will not be easily washed or blown away, but loose enough for the seed to sprout and penetrate the soil. The ideal seedbed includes adequate seed-safe soil that provide conditions for germination and resources for growth.

A seedbed can be produced through shallow plowing, harrowing or dragging small chains. Plowing breaks the upper layer of soil, increasing the number of seed-safe sites and facilitating seedling germination and root expansion. Plowing should be carefully considered, for it may permanently damage any desired vegetation and can facilitate erosion on slopes or fine-textured soils. Always avoid deep plowing on sites with invasive weeds; it promotes nitrogen release, which favors heavy weed growth. If plowing is absolutely necessary, shallow-plowing just the upper two inches of soil is recommended. Disc plows are often harmful to soil structure and should not be used as a means of mitigating compaction unless coarse clods, produced when the soil was worked while wet, dominate the site.

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Nitrogen fertilizers should only be used when a soil test has revealed a nitrogen deficiency or in near-arid sites when agronomic species such as tall fescue (Festuca arundinacea) are seeded when rapid growth and maximum production is desired. Smooth bromegrass (Bromus inermis) may require nitrogen fertilizer if the soil is not sufficiently fertile (Smolina et al., 1990). The high nitrogen requirements of these non-native grasses make them well suited for use in mixtures with nitrogen-fixing legumes such as alfalfa.

Rarely is nitrogen needed for native species, especially legume grasses such as bluebunch wheatgrass (Pseudoroegneria spicata agg. spicata); see box overhead. These grasses have minimal nitrogen requirements, having evolved in low-nitrogen environments. In many revegetation cases, reducing the amount of available nitrogen in the soil can increase late-seal grass establishment by reducing weed interference. For this reason, when seeding late-seal native grasses such as bluebunch wheatgrass in moderate- or high-nitrogen sites, consider seeding a sterile cover crop such as Raggiana or tractor-tied that can quickly sequester nitrogen. This nutrient reduction will hinder the growth of non-native weeds while fostering the late-seal seeded species.

Cover crops further favor seeded species by providing quick protection to seeds and soil from erosion by wind and water, conserving soil moisture from the effects of wind and sun, and moderating soil temperatures.
The addition or reduction of nitrogen can have significant effects on various crop growth. The reduction of soil nitrogen through cover crop sequestration can benefit native grasses. The addition of non-essential nitrogen reduces important mycorrhizal activity (St. John 1997) and encourages heavy weed growth that overwhelms slower-growing natives. In a southeastern Montana study, the main responses to nitrogen fertilization in a dry-land situation were increased annual grass or annual weed production and decreased diversity (Hertzog 1983). Avoid nitrogen additions when seeding native grazed.

Soil microorganisms process mulch and dead plant material into a form available for plant uptake, essential for nutrient cycling. Important microorganisms include bacteria, protozoa and fungi. Mycorrhizal fungi contribute to plant growth and survival in degraded habitats. These fungi develop a beneficial relationship with plants known to improve phosphorus uptake, drought tolerance and resistance to pathogens. These microorganisms also benefit nitrogen cycling, enhance the transport of water (improving drought resistance) and increase offspring quality, contributing to long-term reproductive success and fitness of the species (Kocurek et al. 1995). Mycorrhizal inoculation of locally sourced or salvaged nitrogen-fixing plants or nursery stock can be highly beneficial to a project. Place inoculants below the seedling at transplant stage or dip bare root stock in adhesive-metal inoculum.

You can establish mycorrhizal fungi naturally by collecting the top layer layer from a local native weed-free landscape and working it into the soil or by planting thistles that can capture wind-borne tops and mycorrhizal spores.
Step 6
Reduce weed interference

Successful establishment of seeded species often depends on adequate soil moisture and the elimination or significant reduction of invasive weed competition or interference. When revegetating weed-infested sites, strategies are available to reduce weed competition for resources that seeded species require for germination and successful establishment. These strategies may include managing infestations with herbicides or grazing domestic sheep on, for the first couple of years prior to seeding (or longer), mowing to weaken an infestation and significantly reduce competition for light, water and nutrient resources. For instance, mowing spotted knapweed can be effective in preventing seed production and weakening an infestation. In a Montana State University study, mowing as the single management tool decreased spotted knapweed density by 85 percent when performed during the early bud stage (Radicl et al. 2001). A further reduction in density may be anticipated when integrating mowing with other management tools. Combining mowing with an appropriate herbicide applied one month after the last mowing cycle to the rapidly developing regrowth can be effective. Removing plants that have acclimated to frequent mowing by growing prostrate or low to the ground can be accomplished through herbicide treatments or hand-pulling. Consider mowing and applying a herbicide in a single, efficient entry with a wet-blade mower (see Appendix B, p. 65).

Reducing the availability of nutrients to weeds can reduce weed interference with seeded species, especially late-seal native grasses. Sites high in such nutrients as nitrogen favor quick-growing invasive weeds; sites with low nitrogen favor slow-growing late-seal native grasses. Heroux (1999) found that seeding cereal rye (Secale cereale), an early-seal cover crop, dramatically lowered nitrogen and shifted the competitive advantage from spotted knapweed to bluebunch wheatgrass. Past-growing cover crops sequester soil nitrogen and reduce weed interference by depriving weeds of some of this resource. To reduce nutrients in sites with high soil nitrogen, consider planting an early-seal cover crop the year before revegetating with native, late-seal grasses.

Another strategy to reduce weed interference is a fall-dormant no-till drilling operation preceded by a late-season non-selective herbicide application such as glyphosate to
remove noxious weeds and invasive grasses such as cheatgrass (Bromus tectorum). When cheatgrass is present, this strategy can substantially reduce competition for early-season moisture the following spring. When invasive forbs are the dominant component, a cost-effective revegetation strategy developed by Shudey et al. (2001) has proved successful. It uses picloram and a no-till drill in a single field entry (see text box opposite). Young grass seedlings can be sensitive to many herbicides. Universal recommendations for herbicides are beyond the scope of this document. However, some generalizations can be set forth. According to the USDA Natural Resources Conservation Service (2000), the application of bromoxynil at the three- or four-leaf stage enables early suppression of young broadleaf weeds; 2,4-D may be applied once the grass seedlings have reached the four- to six-leaf stage, or later. On the other hand, Shudey et al. (2001) found the application of picloram at 1 or 1 pint per acre did not injure seeded grasses, even with the two- to three-year soil residual. But grass injury did occur when picloram was applied at two quarts per acre. Contact your county or reservation Extension agent or weed coordinator for herbicide recommendations specific to your site. Always follow herbicide label instructions regarding safe handling and application rates.
"Single-entry" revegetation

Weed control is often short-lived in areas dominated by summer weeds because desired species are not available to occupy niches opened by weed control practices. Weed-infested sites lacking an adequate understorey of desired species require revegetation (Burton et al. 1991) for successful long-term weed management. However, revegetation of weed-infested sites is often expensive because of the number of species required for success and the number of field treatments needed to maximize the potential for seedling establishment (Cleekley et al. 1980).

The revegetation of weed-infested sites has commonly required multiple entries:

1. The site is tilled to loosen the soil surface and encourage germination of weed seeds.

2. A few weeks later, a non-selective herbicide (glyphosate) is applied to manage newly emerging weeds; the combination of glyphosate and herbicide reduces weed seed density and weed competition for following crops.

3. Following the herbicide application, fall-planted grains are seeded with a no-till drill.

4. The following spring, the remaining weed seeds and seeded grain germinate and emerge; with adequate spring precipitation, both weed and grain seedlings emerge. If grass seedlings survive until midsummer, a broadleaf herbicide (2,4-D) is applied to reduce weed competition.

In short, successful revegetation of weed-infested sites can be expensive. By contrast, a "single-entry" approach can detect cost-effective and reliable reseeding. In one case, a fall-planted cereal with residual broadleaf herbicide can be applied at the time the grains are seeded with a no-till drill. Cleekley et al. (2001) combined eight herbicide treatments and three grass species in two fertilizer rates to evaluate growth and yield. The best reseeding success resulted from the fall application of 15 kg of 15-15-15 per acre with "Louis palmer" wheatgrass. A "single-entry" approach can improve the soil surface. This cost-effective and reliable "single-entry" strategy can be a major component of many sustainable weed management programs.
Step 7
Design a seed mix

Because every site is unique and seed mixes should be customized to the reestablishment goals, soils and environmental conditions of the site. When selecting species, varieties or cultivars, choose those that are most appropriate for your site’s conditions. If a preferred variety is not available, make sure the second-choice seed originated within a 500-mile radius of the site to be reestablished (Compton and Wierman 2000). Avoid purchasing preformulated wildflower seed mixes. A recent University of Washington study found that 19 packets of wildflower seed mixes contained anywhere from 1 to 13 invasive species. Rather than buy preformulated mixes, buy wildflower seeds species by species and make sure they are native to the region.

Determining an appropriate seed mix should initially be based on reestablishment goals or management objectives of the area, such as to—

1. Improve rangeland/forage production or rehabilitate degraded or disturbed areas
2. Quickly reestablish vegetation to minimize erosion
3. Establish species that can minimize weed invasion or reestablishment and
4. Restore a healthy plant community.

* * *

Once reestablishment goals have been determined, site characteristics such as soil attributes, precipitation, temperature, and elevation, climate, or further direct species selection. (Land USDA Natural Resources Conservation Service field officers or county and reservation Extension agents and weed coordinators are the sources of information on environmental and establishment requirements. They can assist in designing a proper site mix that addresses species compatibility and avoids niche overlap to prevent purchasing seeds that may be displaced over time.

Take care to ensure adequate diversity in reestablishment. Compton and Wierman (2000) advise that several species of grasses should be seeded to cover the range of site conditions and increase reestablishment success (see table 5, p. 36, for recommended mixes by zone for western Montana). When developing a mix, avoid niche overlap and consider species compatibility as some species have very good seedling vigor. These species develop rapidly, often at the expense of other species in the seed mix. For instance, tall wheatgrass (Elymus trachycaulus) is

Revegetation Guidelines for Western Montana
smooth brome, both non-native, should be seeded alone, for each will completely dominate a site after four or five years. Species characterized by slower-developing, non-aggressive seedlings, such as non-native Russian wildrye (Poastrachy juncea) and tall fescue, should also be seeded alone (USDA 1996). Birdsfoot trefoil (Lotus corniculatus), as introduced legumes, is intolerant of competition from other plants and in any case grow best alone (Smoliak et al. 1950). If weeds are present, competition-intolerant species should not be considered. Unless the site is to be grazed, avoid mixing tall-growing grasses with such shade-intolerant legumes as birdsfoot trefoil. Such grasses can suppress legume performance.

When purchasing seed, ensure that the mix is weed-free. To improve both quality and establishment results, specify certified seed. Only cultivated, named varieties such as 'Luna' and 'Can- fax' can be certified. (Bag of such seed bar blue 'certified seed' tags) Certification guarantees that the seed has the same genetic potential to perform in the field as did the breeder seed of the variety when it was first released for production. For instance, when purchasing certified 'Tettra' intermediate wheatgrass (Elyrigia triticea sp. intermedius), you are sure to have dwarf intermediate wheatgrass plus to meet your revegetation goals or land-management objectives.

Recent interest in native wildland seed has prompted a seed certification class for such collections. The "Source Identified Class" verifies the origin and ecotype of a wildland seed harvest.

Seed that is harvested following the approved guidelines and procedures for the Source Identified Class comes with yellow certified seed tags that affirm that the biovariet of the seed harvest was verified by the certification agency.

A list of selected species based on desired use of rangeland use is provided in Table 1, overall. Recommended native grasses and grasslike species are listed in Table 2, pp. 22–25. A list of non-native grasses for typical projects is provided in Table 3, pp. 26–27. And selected forb and shrub species are listed in Table 4, pp. 30–35.

Revegetation goals

1. Improve rangeland diversity production or rehabilitate degraded or disturbed sites

A. Rangeland improvement Many native and non-native species are appropriate for rangeland improvement. Mixtures of species with different palatability are usually not recommended, as some will be overgrazed while others are underutilized. For instance, north-and south-grass (Blye-a canescens) is preferred less than other grasses, and the relatively low palatability of red canarygrass (Phalaris arundinacea) makes it necessary to have pasture fenced separately, giving livestock an alternative. Mixtures should be designed with careful attention to site overlap to avoid reversion to a few species over time. Some find that the
<table>
<thead>
<tr>
<th>Species</th>
<th>Spring</th>
<th>Summer</th>
<th>Fall</th>
<th>Winter</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barleria longissima</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Glyceria religiosa</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Gymnarthrum scoparium</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Galium verum</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Thalictrum thalictroides</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Solidago virgaurea</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Salix lutea</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Rubus idaeus</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Berberis thunbergiana</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Wisteria floribunda</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Paeonia officinalis</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Kaempferia galpinii</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Rubus idaeus</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

The best option is to create a series of dryland pastures with one or more species planted to spring grazing species and then planted to autumn or fall species (Keeleworth et al. 2000). Because these sites tend to maximize niche occupation, frequent monitoring for weeds is encouraged.

Consider the use of the pasture and the ability of the species to supply forage when needed (table 1, left) and design the mix to accommodate seasonal forage requirements. For instance, winterfat (Eriogonum triste) is one of the most valuable plants for maintaining weights of adult animals on winter ranges (Smolak et al. 1990). Guard against weed invasion by including a combination of shallow- and deep-rooted forbs and grasses that grow both early and late in the year to maximize niche occupation in time and soil profile space throughout the year.

Enhanced forage can be provided with a simple mixture of productive cool-season grasses and a deep-rooted legume. This mix will produce more high-quality forage than grass alone. For instance, smooth bromegrass mixed with properly nodulated alfalfa produces yields of hay three times those produced from smooth bromegrass alone. Orchardgrass (Dactylis glomerata) produces yields of hay, but when it is grown with clover or alfalfa, yields of two to three tons per acre may be expected. Similarly, the palatability and nutritive value of tall fescue is improved when it is grown in a legume (Smolak et al. 1996). To avoid blowout, replace...
R Natural area rehabilitation Areas not used for grazing, such as natural areas, should be seeded with native species that provide ecologic stability and maintain plant community integrity. Avoiding the seeding of non-native grasses will guard against their dominance, which could inhibit native community recovery and the potentially alter the diversity of local plants. When designing a seed mix for natural areas, including wetlands, the local landscape or nearby wetlands are good references for species selection based on species occurrence and distribution. Because the seeds are local and thus well adapted to local environmental conditions, germination success and plant hardiness may be increased. Furthermore, the local landscape can provide species that may not be available commercially. However, depending on current-year growing conditions, collected wildland seeds sometimes have low viability. For instance, germination trials of Indian ricegrass (Acasserum hymenoides) revealed that often over half the seeds lack a developed embryo and hence could not germinate (Stoddart and Wilkinson 1980). To offset this disadvantage, the collection of large quantities is required, which can increase collection time and costs unless those costs can be compensated through volunteer labor.

C. Roadside rehabilitation (see Appendix B, p. 65) Roadside often have low fertility and depleted biological activity. This reduces the establishment and persistence of vegetative stands (Clayton and Zasada 1993) and limits long-term vegetation success. To increase long-term success, healthy topsoil additions will [Continued from p. 21] serve as a source of nutrients, plant propagules will [Continued on p. 3]
<table>
<thead>
<tr>
<th>Name</th>
<th>Habitat</th>
<th>Growth form</th>
<th>Proliferation</th>
<th>Minimun preplanting (months)</th>
<th>Tolerance control</th>
<th>Post-stand &quot;old age&quot; (months)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safflower</td>
<td>Short to short-mid, hard-annual</td>
<td>Short-</td>
<td>Basins, flat breaks, Cheat</td>
<td>Seed as ready</td>
<td>6</td>
<td>Good</td>
<td>22</td>
</tr>
<tr>
<td>Malva specularis</td>
<td>Short to short-mid, hard-annual</td>
<td>Short-</td>
<td>Basins, flat breaks, Cheat</td>
<td>Seed as ready</td>
<td>10</td>
<td>Good</td>
<td>8</td>
</tr>
<tr>
<td>Sunflower</td>
<td>Short to short-mid, hard-annual</td>
<td>Short-</td>
<td>Basins, flat breaks, Cheat</td>
<td>Seed as ready</td>
<td>10</td>
<td>Very good</td>
<td>10</td>
</tr>
<tr>
<td>Mesquite (Palo Verde)</td>
<td>Short to short-mid, hard-annual</td>
<td>Short-</td>
<td>Basins, flat breaks, Cheat</td>
<td>Seed as ready</td>
<td>16</td>
<td>Good</td>
<td>15</td>
</tr>
<tr>
<td>Agave victoriae</td>
<td>Short to short-mid, hard-annual</td>
<td>Short-</td>
<td>Basins, flat breaks, Cheat</td>
<td>Seed as ready</td>
<td>6</td>
<td>Good</td>
<td>2</td>
</tr>
<tr>
<td>Agave victoriae</td>
<td>Short to short-mid, hard-annual</td>
<td>Short-</td>
<td>Basins, flat breaks, Cheat</td>
<td>Seed as ready</td>
<td>10</td>
<td>Good</td>
<td>4</td>
</tr>
<tr>
<td>Safflower</td>
<td>Short to short-mid, hard-annual</td>
<td>Short-</td>
<td>Basins, flat breaks, Cheat</td>
<td>Seed as ready</td>
<td>6</td>
<td>Very good</td>
<td>19</td>
</tr>
<tr>
<td>T sediflorus</td>
<td>Short to short-mid, hard-annual</td>
<td>Short-</td>
<td>Basins, flat breaks, Cheat</td>
<td>Seed as ready</td>
<td>20</td>
<td>Good</td>
<td>7</td>
</tr>
</tbody>
</table>

22. Revetement Guidelines for Western Mustangs
Table 2. Native grasses and grasslike species, cont'd

<table>
<thead>
<tr>
<th>Name</th>
<th>Cultivar</th>
<th>Greek form</th>
<th>Preferred soil type</th>
<th>Abundant plantings (因地制宜)</th>
<th>Emergence control</th>
<th>Root spread PLO unit (inmom) (年)</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Love-winter</td>
<td>Medium</td>
<td>Medium-all baccharis</td>
<td>Sandy</td>
<td>12</td>
<td>Very good</td>
<td>15</td>
<td>Rapid establishment, down hard, holds more or periodically, well drained soil. Good palatability, may vary depending on seedling controls.</td>
</tr>
<tr>
<td>Rough brome</td>
<td>Medium</td>
<td>Medium-all baccharis</td>
<td>Möve/loose</td>
<td>13</td>
<td>Good</td>
<td>50</td>
<td>improves on porous unfrozen, well drained soil. Establishment on a wide variety of soil types. Controls for weedy and invasive, good range for wildlife.</td>
</tr>
<tr>
<td>Prairie grass</td>
<td>Medium</td>
<td>Medium-all baccharis</td>
<td>Sandy</td>
<td>12</td>
<td>Good</td>
<td>2</td>
<td>Drains slowly, easy establishment. Combat when more water is drained and controls to use prairie problems. Not subject to hairy root disease growing</td>
</tr>
<tr>
<td>Barren brome</td>
<td>Cold, Star</td>
<td>Medium-all baccharis</td>
<td>Mix-loose</td>
<td>10</td>
<td>Good</td>
<td>8-12</td>
<td>Drains slowly, moderate establishment.</td>
</tr>
<tr>
<td>Needle and steel</td>
<td>Short</td>
<td>Medium-all baccharis</td>
<td>Crop</td>
<td>15</td>
<td>Poor</td>
<td>4</td>
<td>Valuable pasture for nonwoody, tall biomass, or when wetlands occasionally survive in standing water.</td>
</tr>
</tbody>
</table>

Seed a seed mix

1. Adapted to wide soil and climate limits. 2. Requires moderate palatability and adaptability to standing water or periodic flooding.
3. Control seedling growth per 40 kg of seed. 4. Encourages less-competitive, more desirable species.
<table>
<thead>
<tr>
<th>Name</th>
<th>Codeword</th>
<th>Growth form</th>
<th>Preferred soil type</th>
<th>Minimum precipitation (inches)</th>
<th>Erosion control</th>
<th>Pure stand - P&amp;L to toy (years)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avereonjae (Digitalis mora)</td>
<td>—</td>
<td>Spat.-cord.</td>
<td>Clay/Clay loam</td>
<td>8</td>
<td>Good</td>
<td>5</td>
<td>Greatly preferred adapted to subtropical wet areas; prone to erosion</td>
</tr>
<tr>
<td>Medium to medium-all diomeses —</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snyeckokah wobagam (Gymea ericoides, sp. pauciflora)</td>
<td>Solar</td>
<td>Medium-all diomeses</td>
<td>Sandy to clay</td>
<td>8</td>
<td>Excellent</td>
<td>12</td>
<td>Drudgery soluble; Medium plant density; shows foliage super well suited for stabilizing highly eroded slopes in sandy soils</td>
</tr>
<tr>
<td>Magamagam (Gymea ericoides)</td>
<td>—</td>
<td></td>
<td>Clay</td>
<td>18 (or wet areas)</td>
<td>Good</td>
<td>12</td>
<td>Adapted to stream banks, muddy, and wet areas</td>
</tr>
<tr>
<td>Bready whacky (Gymea serrata)</td>
<td>Solar</td>
<td>Medium-all diomeses</td>
<td>Sandy/loamy clay</td>
<td>10</td>
<td>Very good</td>
<td>20</td>
<td>Moderately drudgery soluble; difficult to establish; shows foliage well suited for stabilizing poorly drained soils; very palatable for improving wildlife ranges</td>
</tr>
<tr>
<td>Western wobagam (Oreganum multilobum)</td>
<td>Sunfast, Red, Vegetables</td>
<td>Medium-all diomeses</td>
<td>Silky-loamy to clay</td>
<td>10 (or riparian)</td>
<td>Poor</td>
<td>15</td>
<td>Drudgery soluble; poorly suited to establish; shows foliage; good for slightly shaded, summer soils, where long-term hardy vegetation is desired and rapid establishment is not</td>
</tr>
<tr>
<td>Harpoon wobagam (Pseudowagam, gymea sp. varrius)</td>
<td>Whorl</td>
<td>Medium diomeses</td>
<td>Silky-loamy</td>
<td>15-15</td>
<td>Good</td>
<td>12</td>
<td>Fairly established; long lived; intermediate of poor drainage; high water table and spring flooding</td>
</tr>
<tr>
<td>Tall diomeses —</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avereonjae drakkle (Drothicus angustus)</td>
<td>Epa</td>
<td>Tall diomeses</td>
<td>Silky-loamy to clay</td>
<td>25</td>
<td>Excellent</td>
<td>19</td>
<td>Annual or short-lived potential 5-5 years adapted to wet sites; generally developed for erosion control in semi-arid wet areas</td>
</tr>
<tr>
<td>Bready whacky (Calamagrostis canadensis)</td>
<td>Secalina</td>
<td>Tall diomeses</td>
<td>Silky-loamy to clay</td>
<td>10</td>
<td>Very good</td>
<td>4</td>
<td>Easy establishment; adapted to wide and riparian sites; Secalina/developed for ability to establish early under soil stabilizing characteristics</td>
</tr>
<tr>
<td>Thudkang whacky (Gymea tenuis, sp. tenuissima)</td>
<td>Reancho, Cynnea, Sedes-bone</td>
<td>Medium diomeses</td>
<td>Sandy to clay</td>
<td>8</td>
<td>Excellent</td>
<td>12</td>
<td>Drudgery soluble; easy for feral bwood; long-lived; good soil stability; palatable</td>
</tr>
</tbody>
</table>

1. Adapted to saline soils and clitter soils. 2. Requires medium to large quantities of water or wetter sites. 3. Established more easily in areas with special drainage problems or intense snow. 4. Based on past work. 5. Calamagrostis canadensis. 6. In diomeses tolerates wide and special dry soils involving increased erosion.

Revegetation Guidelines for Western Montana
<table>
<thead>
<tr>
<th>Name</th>
<th>Cultivar</th>
<th>Growth from</th>
<th>Preferred soil type</th>
<th>Minimum precipitation (inches)</th>
<th>Season control</th>
<th>Pest and yield problems</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sedge</strong>&lt;sup&gt;1&lt;/sup&gt; (Cyperus spp.)</td>
<td>---</td>
<td>Perennial on rhizomes</td>
<td>Clayey</td>
<td>(Wet area)</td>
<td>Good</td>
<td>2-3</td>
<td>Adapted to wet meadows, meadow wilds, or shallow swamps. (Blackbird, cut, 2.40m or more on other Cultivars.)</td>
</tr>
<tr>
<td><strong>Sphagnum</strong>&lt;sup&gt;2&lt;/sup&gt; (Sphagnum spp.)</td>
<td>---</td>
<td>Sphagnum</td>
<td>Clayey</td>
<td>(Wet area)</td>
<td>Good</td>
<td>2-3</td>
<td>Fast establishment. Choose in wet meadows without mud. Useful for quick succession.</td>
</tr>
<tr>
<td><strong>Sedges</strong>&lt;sup&gt;3&lt;/sup&gt; (Carex spp.)</td>
<td>---</td>
<td>Sedges or tall grasses</td>
<td>Clayey</td>
<td>12</td>
<td>(Wet area)</td>
<td>Good</td>
<td>20</td>
</tr>
<tr>
<td><strong>Palisade</strong>&lt;sup&gt;4&lt;/sup&gt; (Carex spp.)</td>
<td>---</td>
<td>Palisades or tall grasses</td>
<td>Clayey</td>
<td>(Wet area)</td>
<td>Very good</td>
<td>20</td>
<td>Adapted to wet meadows, marshes, swamps, or wet muddy soils. Permits edibles.</td>
</tr>
<tr>
<td><strong>Cattail</strong>&lt;sup&gt;5&lt;/sup&gt; (Typha angustifolia)</td>
<td>---</td>
<td>Tall rushes</td>
<td>Clayey</td>
<td>(Wet area)</td>
<td>Very good</td>
<td>20</td>
<td>Slow to establish and reproduce well. Widely adapted and can become aggressive. Good for wet areas for wildlife.</td>
</tr>
</tbody>
</table>

**Wet meadow grasses**

<table>
<thead>
<tr>
<th>Name</th>
<th>Cultivar</th>
<th>Growth from</th>
<th>Preferred soil type</th>
<th>Minimum precipitation (inches)</th>
<th>Season control</th>
<th>Pest and yield problems</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peat sedge</strong>&lt;sup&gt;6&lt;/sup&gt; (Deshcam paniceum)</td>
<td>---</td>
<td>Sedges</td>
<td>Sandy</td>
<td>10</td>
<td>(Wet area)</td>
<td>Good</td>
<td>6</td>
</tr>
<tr>
<td><strong>Alpine sedge</strong>&lt;sup&gt;7&lt;/sup&gt; (Carex alpinae)</td>
<td>---</td>
<td>Alpine sedge</td>
<td>Sandy</td>
<td>6</td>
<td>(Wet area)</td>
<td>Poor</td>
<td>3</td>
</tr>
<tr>
<td><strong>Glaucous sedge</strong>&lt;sup&gt;8&lt;/sup&gt; (Carex rossii)</td>
<td>---</td>
<td>Glaucous sedge</td>
<td>Sandy</td>
<td>10</td>
<td>(Wet area)</td>
<td>Very good</td>
<td>2</td>
</tr>
</tbody>
</table>

**Rhizomes**

<table>
<thead>
<tr>
<th>Name</th>
<th>Cultivar</th>
<th>Growth from</th>
<th>Preferred soil type</th>
<th>Minimum precipitation (inches)</th>
<th>Season control</th>
<th>Pest and yield problems</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inland sedges</strong>&lt;sup&gt;9&lt;/sup&gt; (Carex rossii)</td>
<td>---</td>
<td>Inland sedge</td>
<td>Clayey</td>
<td>8</td>
<td>(Wet area)</td>
<td>Poor</td>
<td>10</td>
</tr>
</tbody>
</table>

1. Adapted to wet meadow wilds. 2. Requires waterlogging to prevent root rot. 3. Sedges should provide forage early in the season. 4. Slow to establish. 5. Palisades should be planted on the wettest sites. 6. Peat sedge should be planted on the wettest sites. 7. Alpine sedge should be planted on the wettest sites. 8. Glaucous sedge should be planted on the wettest sites. 9. Inland sedges should be planted on the wettest sites. 10. Adapted to wet, saline clay soils. Useful for extensively altered sites. Usually grown with alaska moss and prairie cattails. Often established by spreading.
### Table 3. Non-Native grasses recommended for western Montana reseeding projects (all cool-season unless noted otherwise)

<table>
<thead>
<tr>
<th>Name</th>
<th>Caliber</th>
<th>Growth form</th>
<th>Palatable self type</th>
<th>Minimum precipitation (inches)</th>
<th>Erosion control</th>
<th>Pure annual PPI rate/yr (pounds)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ammodeum</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual pogyra (Ammodeum atratum)</td>
<td>Gulf</td>
<td>Tall annual</td>
<td>Slipy-bunny</td>
<td>8</td>
<td>Very good</td>
<td>16-35</td>
<td>Annual, quick and easy establishment. Highly palatable to domestic and wildlife.</td>
</tr>
<tr>
<td>Bryopyrum (Bryopyrum x tallifolium)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Greek willow x tallifolium)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Greek aster x tallifolium)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bromus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Bromus tectorum)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Bromus sterilis)</td>
<td></td>
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<td>(Digitaria sanguinalis)</td>
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<td><strong>Eragrostis</strong></td>
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<td>(Eragrostis curvula)</td>
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<tr>
<td>(Eragrostis linearis)</td>
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<td><strong>Rumex</strong></td>
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<td>(Rumex crispus)</td>
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<td>(Rumex crispus)</td>
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<td><strong>Setaria</strong></td>
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<td>(Setaria viridis)</td>
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<td>(Setaria viridis)</td>
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<td><strong>Stipa</strong></td>
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<td><strong>Trisetum</strong></td>
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</tbody>
</table>

*Annual pogyra (Ammodeum atratum) and annual pogyra (Ammodeum atratum) are used as a self-seeding and come up to early- to mid-summer. Quick and easy establishment does not compete or outcompete. Will be considered in-habitat by many desired species. Decrease interference.*

---

**Revegetation Guidelines for Western Montana**
<table>
<thead>
<tr>
<th>Name</th>
<th>Culture</th>
<th>Growth form</th>
<th>Perennial soil type</th>
<th>Minimum precipitation (inches)</th>
<th>Erosion control</th>
<th>Frost hardiness</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow Sweetclover</td>
<td>Medium</td>
<td>Shallow/loose</td>
<td>8</td>
<td>Very good</td>
<td>8-11</td>
<td>Easy establishment: Suffer to establish, easy to mature once established, dense, stable, good for erosion.</td>
<td></td>
</tr>
<tr>
<td>Red clover</td>
<td>Large</td>
<td>Shallow/loose</td>
<td>25 (in wood)</td>
<td>Good</td>
<td>4-5</td>
<td>Slow establishment, long head. Adapted to wet, well-drained sites and moisture. Good for erosion control, frost hardy.</td>
<td></td>
</tr>
<tr>
<td>Purple clover</td>
<td>Medium</td>
<td>Shallow/loose</td>
<td>12</td>
<td>Very good</td>
<td>15-15</td>
<td>Rapid establishment, short head. Useful for pasture and hedge improvement. Excellent popularity.</td>
<td></td>
</tr>
<tr>
<td>Perennials</td>
<td>Native</td>
<td>Shallow/loose</td>
<td>10</td>
<td>Good</td>
<td>8-10</td>
<td>Easy establishment. Adapted to meadows, late season. Can be grown in pastures or hay crops and for erosion/spoil. Excellent popularity.</td>
<td></td>
</tr>
</tbody>
</table>

All listed species are perennials, except for Yellow Sweetclover, which is annual. These species are suitable for most soil types and are known to be frost hardy.

1. Adapted to native soil and/or dry soils. 2. Preferred soil for erosion control or prairie restoration.

3. Agerative species that can be invasive. Use is recommended in areas where they are not a concern and do not spread uncontrollably.

4. Based on seed mix — see Fig. 18. "Califia's mixing rules," p. 15. 5. Suitable for use in grass and special sites involving increased costs.

Sign a seed mix 27
<table>
<thead>
<tr>
<th>Name</th>
<th>Culture</th>
<th>Growth form</th>
<th>Preferred soil type</th>
<th>Minimum precipitation (inches)</th>
<th>Erosion control</th>
<th>Poor soil tillage (years) (months)</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creeping willow*  (Salix repens)</td>
<td>Generic, Brian</td>
<td>Med-LOW</td>
<td>Silt-loam</td>
<td>25 (or more)</td>
<td>Good</td>
<td>4</td>
<td>Made in establishment, long lived. Adapted to wet or poorly drained soils. Requires shallow root zone. Very valuable for erosion. Well suited for slope and cut slope.</td>
</tr>
<tr>
<td>Juniperus virginiana (Yucca filifera)</td>
<td>Generic, Brian</td>
<td>Med-LOW</td>
<td>Silt-loam</td>
<td>16 (or more)</td>
<td>Good</td>
<td>12-17</td>
<td>Good long-lived. Many Establishment. For establishment, long lived. For production, form growth in early spring, cones in early summer, and pollination. Excellent for erosion, slope, and cut slope. Highly valuable when grown. Suitable for slopes, ravines, and cut slopes.</td>
</tr>
<tr>
<td>Quercus muehlenbergii (Tilia americana)</td>
<td>Hardy</td>
<td>Med-LOW</td>
<td>Silt-loam</td>
<td>10 (or more)</td>
<td>Poor</td>
<td>8</td>
<td>Easy establishment. Moderate to long lived. Adapted to a wide variety of soils. Highly productive and palatable. Growing conditions. These are selected for their drought tolerance.</td>
</tr>
<tr>
<td>Red oak (Quercus rubra)</td>
<td>Generic, Brian</td>
<td>Med-LOW</td>
<td>Silt-loam</td>
<td>18 (or more)</td>
<td>Good</td>
<td>14</td>
<td>Easy establishment. Adapted to moist, well-drained soils in areas. Useful on both slope and non-slope pastures and woodlands.</td>
</tr>
<tr>
<td>Canada thistle (Cirsium arvense)</td>
<td>Generic, Brian</td>
<td>Med-LOW</td>
<td>Silt-loam</td>
<td>18 (or more)</td>
<td>Good</td>
<td>2</td>
<td>Able to grow in harsh soils including shallow, infertile soils. Useful for improvement of poor soils where new palatable and productive species are not available.</td>
</tr>
<tr>
<td>Field thistle (Erigeron annuus)</td>
<td>Generic, Brian</td>
<td>Med-LOW</td>
<td>Silt-loam</td>
<td>18 (or more)</td>
<td>Poor</td>
<td>3</td>
<td>Adapted to weedy areas and non-prominent areas. Good for erosion control.</td>
</tr>
</tbody>
</table>

Revegetation Guidelines for Western Montana

1. Adapted to slope with shallow soils. 2. Adapted to slope with well-drained soils. 3. Adapted to slope with moderately well-drained soils.

* Aggressive species that can be invasive. Do not attempt to grow when using this species with grass species is advised and one to control area.
<table>
<thead>
<tr>
<th>Name</th>
<th>Culture</th>
<th>Growth form</th>
<th>Preferred soil type</th>
<th>Minimum precipitation (inches)</th>
<th>Tolerated soil pH</th>
<th>Pure seed PILE mean/ acre* (pounds)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tall Selenium</td>
<td>Broadleaf</td>
<td>Tall</td>
<td>Silky linen</td>
<td>8</td>
<td>5.5</td>
<td>15</td>
<td>Predominantly wet or moderately wet soil. Tolerates acidic and nutrient-poor soils and periodic flooding. Used as pasture hay.</td>
</tr>
<tr>
<td>Kentucky bluegrass</td>
<td>Stoloniferous</td>
<td>Tall</td>
<td>Silky linen</td>
<td>14</td>
<td>5.5</td>
<td>15</td>
<td>Moderate moisture tolerant. Easy establishment, low to medium fertility. Sow either in field or in areas where severe cold and lack of snow can occur.</td>
</tr>
<tr>
<td>Ponderosa (Poaceae)</td>
<td>Stoloniferous</td>
<td>Tall</td>
<td>Silky linen</td>
<td>12</td>
<td>5.5</td>
<td>15</td>
<td>Moderate moisture tolerant. Slow establishment, long-lived. Well suited for establishing dryland pastures. Not winter hardy. Can be used for pasture hay.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weed species</th>
<th>Cultivating</th>
<th>Growth form</th>
<th>Preferred soil type</th>
<th>Minimum precipitation (inches)</th>
<th>Tolerated soil pH</th>
<th>Pure seed PILE mean/ acre* (pounds)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedgegrass</td>
<td>Sedgegrass</td>
<td>Tall</td>
<td>Silky linen</td>
<td>14</td>
<td>5.5</td>
<td>15</td>
<td>Annual foraging and moist soils. Often used in mixed mosaic crops.</td>
</tr>
</tbody>
</table>


Design a seed mix
<table>
<thead>
<tr>
<th>Name</th>
<th>Care</th>
<th>Soil type</th>
<th>Minimum precipitation (inches)</th>
<th>Max rain (in.) per week (percent)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portion of the forest is not noted otherwise.</td>
<td></td>
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</tr>
<tr>
<td>Asters</td>
<td>Perennial</td>
<td>Sun to shade</td>
<td>6-12</td>
<td>5-10</td>
<td>Suitable for dry, rocky sites. Requires full sun.</td>
</tr>
<tr>
<td>Rocky Mountain bee plant (Genus gynandrum)</td>
<td>Perennial</td>
<td>Sun to part shade</td>
<td>8-12</td>
<td>8-12</td>
<td>Requires full sun. Good for erosion control.</td>
</tr>
<tr>
<td>Blue false indigo (Bunianus officinalis)</td>
<td>Perennial</td>
<td>Sun to part shade</td>
<td>10-12</td>
<td>10-12</td>
<td>Suitable for dry, rocky sites. Requires full sun.</td>
</tr>
<tr>
<td>Lapin grass (Trias nana)</td>
<td>Annual</td>
<td>Sun to shade</td>
<td>4-6</td>
<td>4-6</td>
<td>Suitable for dry, rocky sites. Requires full sun.</td>
</tr>
<tr>
<td>Deauville goldenrod (Trias gynanthus)</td>
<td>Annual</td>
<td>Sun to shade</td>
<td>6-8</td>
<td>6-8</td>
<td>Suitable for dry, rocky sites. Requires full sun.</td>
</tr>
<tr>
<td>Short perennial forb</td>
<td>Perennial</td>
<td>Sun to shade</td>
<td>12-18</td>
<td>12-18</td>
<td>Suitable for dry, rocky sites. Requires full sun.</td>
</tr>
<tr>
<td>White clover (Trifolium repens)</td>
<td>Annual</td>
<td>Sun to shade</td>
<td>10-12</td>
<td>10-12</td>
<td>Requires full sun. Good for erosion control.</td>
</tr>
</tbody>
</table>

Revegetation Guidelines for Western Montana

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<table>
<thead>
<tr>
<th>Name</th>
<th>Caliber</th>
<th>Soil type</th>
<th>Minimum precipitation (mm)</th>
<th>Pure species (PDL/PC) (present)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buttery Broom (Corylhinum tomentosum)</td>
<td>—</td>
<td>Sandy to sticky</td>
<td>24</td>
<td>7-12</td>
<td>Drought-tolerant. Heavy perennial that attracts butterflies. Blooms late in September.</td>
</tr>
<tr>
<td>Pacific sedge (Azara obscura)</td>
<td>—</td>
<td>Sandy to sticky</td>
<td>12</td>
<td>2</td>
<td>Somewhat drought-tolerant. Blooms July to October. Often found in disturbed habitats. Good erosion control.</td>
</tr>
<tr>
<td>Spanish fescue (Lolium perenne)</td>
<td>—</td>
<td>Sandy to clayey</td>
<td>12</td>
<td>7-15</td>
<td>Drought-tolerant. Blooms May to July along open banks, steep slopes, and in open pine forests. Provides valuable spring food for deer and elk.</td>
</tr>
<tr>
<td>Speckled Indian grass (Stipa comata)</td>
<td>—</td>
<td>Sandy to clayey</td>
<td>10</td>
<td>1</td>
<td>Occurs in wooded areas and meadows and on open, sandy slopes.</td>
</tr>
<tr>
<td>Aspen glacier (Poa secunda)</td>
<td>—</td>
<td>Sandy to clayey</td>
<td>10</td>
<td>1</td>
<td>Blooms June to September. Found on open meadows, along streams, and under aspens. Stems rise to be</td>
</tr>
<tr>
<td>Slender falseflower (Corydalis anonum)</td>
<td>—</td>
<td>Sandy to clayey</td>
<td>10</td>
<td>6-10</td>
<td>Early-spring-flowering and suitable for use in meadows for erosion control.</td>
</tr>
<tr>
<td>Northern meadowfoam (Dichondra anna)</td>
<td>—</td>
<td>Sandy to clayey</td>
<td>10</td>
<td>15-25</td>
<td>Drought-tolerant. Productive and palatable to wildlife and livestock.</td>
</tr>
<tr>
<td>Blue flax (Linum usitatissimum)</td>
<td>Appre</td>
<td>Sandy to clayey</td>
<td>10</td>
<td>5</td>
<td>Drought-tolerant. Easy establishment, drought-tolerant. Adapted to well drained soils. 'Appre' has outstanding vigour and improvements.</td>
</tr>
<tr>
<td>Yellow-green alax (Onosma elatum)</td>
<td>—</td>
<td>Sandy to clayey</td>
<td>10</td>
<td>2</td>
<td>Blooms July and August. Found in disturbed areas. Good for erosion control.</td>
</tr>
<tr>
<td>White clover (Trifolium repens)</td>
<td>—</td>
<td>All types</td>
<td>10</td>
<td>2</td>
<td>Drought-tolerant. Slow spreading into existing grasses, seedheads and groups, especially on well drained grassland soils. Good nutrition and palatability for livestock.</td>
</tr>
<tr>
<td>4x4in masticating leaf bitters (Deschampsia cespitosa)</td>
<td>Delte</td>
<td>Slpy-creamy</td>
<td>10</td>
<td>20-20</td>
<td>4x4in masticating, long-lived. Takes 7 years hardy, moderately drought-tolerant. Valuable for livestock and wildlife in low water and early spring.</td>
</tr>
<tr>
<td>Mugo blacktop (Juncus nigricans)</td>
<td>—</td>
<td>Sandy to sandy</td>
<td>12</td>
<td>4-8</td>
<td>Drought-tolerant. Blooms May to August along meadows, sandy meadows, abandoned fields and other exposed areas.</td>
</tr>
</tbody>
</table>

Design a seed mix: 

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<table>
<thead>
<tr>
<th>Name</th>
<th>Caliber</th>
<th>Soil type</th>
<th>Minimum penetration (inches)</th>
<th>Past crowd PCL values (points)</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium potential forbs, grass*</td>
<td></td>
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</tr>
<tr>
<td>Golden-buttercup (Ranunculus acris)</td>
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</tr>
<tr>
<td>Mule-ear (Wyethiarepens)</td>
<td>3</td>
<td>Shale-buff</td>
<td>16</td>
<td>20-40 (Mule-ear is mostly mature and some woods and dry wooded areas, 10-20 acres are suitable for dry sites in semi-arid areas)</td>
<td></td>
</tr>
<tr>
<td>Forage potential grasses</td>
<td></td>
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<tr>
<td>New England aster (Aster novae-angliae)</td>
<td></td>
<td></td>
<td>16</td>
<td>2 (New England aster) is mostly mature and some woods and dry wooded areas, 10-20 acres are suitable for dry sites in semi-arid areas, 10-20 acres are suitable for dry sites in semi-arid areas)</td>
<td></td>
</tr>
<tr>
<td>Lambsquarters (Chenopodiumsp.)</td>
<td></td>
<td></td>
<td>16</td>
<td>8-10 (Lambsquarters are mostly mature and some woods and dry wooded areas, 10-20 acres are suitable for dry sites in semi-arid areas)</td>
<td></td>
</tr>
<tr>
<td>Purple sand Verbena (Verbena asperula)</td>
<td></td>
<td></td>
<td>12</td>
<td>7-12 (Purple sand Verbena is mostly mature and some woods and dry wooded areas, 10-20 acres are suitable for dry sites in semi-arid areas)</td>
<td></td>
</tr>
<tr>
<td>Flag-leaf (Plantago palustris)</td>
<td></td>
<td></td>
<td>8</td>
<td>0.5 (Flag-leaf is mostly mature and some woods and dry wooded areas, 10-20 acres are suitable for dry sites in semi-arid areas)</td>
<td></td>
</tr>
<tr>
<td>Wild petunia (Petunia integrifolia)</td>
<td></td>
<td></td>
<td>14</td>
<td>10-12 (Wild petunia is mostly mature and some woods and dry wooded areas, 10-20 acres are suitable for dry sites in semi-arid areas)</td>
<td></td>
</tr>
<tr>
<td>Nuttall's sunflower (Helianthus nuttallii)</td>
<td></td>
<td></td>
<td>14</td>
<td>6-12 (Nuttall's sunflower is mostly mature and some woods and dry wooded areas, 10-20 acres are suitable for dry sites in semi-arid areas)</td>
<td></td>
</tr>
<tr>
<td>Rocky Mountain penstemon (Penstemon magellanica)</td>
<td></td>
<td></td>
<td>14</td>
<td>3-4 (Rocky Mountain penstemon is mostly mature and some woods and dry wooded areas, 10-20 acres are suitable for dry sites in semi-arid areas)</td>
<td></td>
</tr>
<tr>
<td>Purple mariposa (Erythranthes bloomiana)</td>
<td></td>
<td></td>
<td>12</td>
<td>6-0 (Purple mariposa is mostly mature and some woods and dry wooded areas, 10-20 acres are suitable for dry sites in semi-arid areas)</td>
<td></td>
</tr>
<tr>
<td>Forage Legumes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Seedling size (Clonal basis)</td>
<td></td>
<td></td>
<td>3 (Forage legumes are mostly mature and some woods and dry wooded areas, 10-20 acres are suitable for dry sites in semi-arid areas)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Calcareous</td>
<td>Salt type</td>
<td>Minimum 15-15-15 ppm (lb/acre)</td>
<td>Poor seed (%)</td>
<td>Moisture</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------</td>
<td>-----------</td>
<td>--------------------------------</td>
<td>--------------</td>
<td>----------</td>
</tr>
<tr>
<td>Desert Century</td>
<td>Rare,</td>
<td>Silty-loamy</td>
<td>15</td>
<td>6</td>
<td>Slow establishment, long-lived. Adjust soil to warm and poorly drained sites; cold-season growers, flowers and fruit intolerant; valuable for ornamentals and as a potential forage.</td>
</tr>
<tr>
<td>Legume (G. stylosa)</td>
<td>–</td>
<td>Silty-loamy</td>
<td>12-16</td>
<td>10-25</td>
<td>Generally found on dry, open, chalky sites.</td>
</tr>
<tr>
<td>Alfalfa (Medicago sativa)</td>
<td>Rare,</td>
<td>Silty-loamy</td>
<td>12</td>
<td>15</td>
<td>Poor drainage, must be protected from wet soils.</td>
</tr>
<tr>
<td>C. H. RAEVEE</td>
<td>Rare,</td>
<td>Silty-loamy</td>
<td>12</td>
<td>15</td>
<td>Drought-tolerant, may be susceptible to leaf blight.</td>
</tr>
<tr>
<td>Saltbush (Atriplex)</td>
<td>Rare,</td>
<td>Silty-loamy</td>
<td>12</td>
<td>35-45</td>
<td>Drought-tolerant, may require irrigation in dry years.</td>
</tr>
<tr>
<td>Buckwheat (Fagopyrum)</td>
<td>Rare,</td>
<td>Silty-loamy</td>
<td>12</td>
<td>35-45</td>
<td>Drought-tolerant, may require irrigation in dry years.</td>
</tr>
<tr>
<td>Verbena (V. angustifolia)</td>
<td>Rare,</td>
<td>Silty-loamy</td>
<td>12</td>
<td>35-45</td>
<td>Drought-tolerant, may require irrigation in dry years.</td>
</tr>
<tr>
<td>Wash (V. fruticans)</td>
<td>Rare,</td>
<td>Silty-loamy</td>
<td>12</td>
<td>35-45</td>
<td>Drought-tolerant, may require irrigation in dry years.</td>
</tr>
</tbody>
</table>

1. Avoid the use of salt for alfalfa sods. 2. Require well-drained sites or perennials well in standing water or periodic flooding.
5. Perennial growth should not be used in humid areas because it may become aggressive.

Desert a seed mix

33
<table>
<thead>
<tr>
<th>Name</th>
<th>Cautious</th>
<th>Soil type</th>
<th>Minimum precipitation (inches)</th>
<th>Few-rated #10 occupancy (percent)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Douglas-fir (P. douglasii)</td>
<td>Silty-loamy</td>
<td>0</td>
<td>(Very)</td>
<td>Adult moisture, may form stands when occurring from 0.00 - 4.00 in. dry soils. Fairly adaptable to browse.</td>
<td></td>
</tr>
<tr>
<td>Ponderosa pine (P. ponderosa)</td>
<td>Silty-loamy</td>
<td>10</td>
<td>(Very)</td>
<td>needles only dry adapted to a wide variety of soils from 0.00 - 5.00 in. Good stands quality and early coniferous seed is hard seed. Fairly tolerant to browse.</td>
<td></td>
</tr>
<tr>
<td>Jeffers - Medium shrubs -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sagebrush (Artemisia spp.)</td>
<td>Sandy Clay</td>
<td>8-12</td>
<td>(Very)</td>
<td>Douglas-sagebrush. Many species and growth forms available from self-styling to non-styling. Resistant to browsing and to the environmental conditions near browse.</td>
<td></td>
</tr>
<tr>
<td>Pinyon-juniper (Pinus edulis)</td>
<td>Sandy-loamy</td>
<td>8</td>
<td>(Very)</td>
<td>Pinyon-juniper. Occurs on all soil textures as wide variety of sizes. Moderately palatable.</td>
<td></td>
</tr>
<tr>
<td>Rabbitbrush (Chrysothamnus spp.)</td>
<td>Sandy-clay</td>
<td>8</td>
<td>(Very)</td>
<td>Rabbitbrush. Occurs on all soil textures as wide variety of sizes. Moderately palatable.</td>
<td></td>
</tr>
<tr>
<td>Bluebunch (Diplacus villosus)</td>
<td>Sandy-loamy</td>
<td>8</td>
<td>(Very)</td>
<td>Bluebunch. Broadleaf buckwheat. Moderate to strong resistance from 2.500 - 5.000 ft.</td>
<td></td>
</tr>
<tr>
<td>Frostweed (Euthamia trifida)</td>
<td>Sandy-loamy</td>
<td>8</td>
<td>(Very)</td>
<td>Frostweed. Moderate resistance from 2.500 - 5.000 ft.</td>
<td></td>
</tr>
<tr>
<td>Saltbush (Atriplex spp.)</td>
<td>Loamy</td>
<td>8-10</td>
<td>(Very)</td>
<td>Douglas-sagebrush. Useful and palatable where high quality browse is good.</td>
<td></td>
</tr>
<tr>
<td>Four o'clock (Euphorbia spp.)</td>
<td>Silty-loamy</td>
<td>10-16</td>
<td>(Very)</td>
<td>Needs a site (free moisture) may not occur. Does not occur from 2.000 - 6.000 ft. Moderate to strong resistance from 2.000 - 5.000 ft. Moderate resistance from 10-100.</td>
<td></td>
</tr>
<tr>
<td>Swampbeauty (Scrophularia spp.)</td>
<td>Silty-loamy</td>
<td>10-16</td>
<td>(Very)</td>
<td>Swampbeauty. Moderate resistance from 2.500 - 5.000 ft. Moderate resistance from 10-100.</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Caldera</td>
<td>Self-type</td>
<td>Minimum precipitation (inches)</td>
<td>Past stand fire interval (years)</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------</td>
<td>-----------------</td>
<td>-------------------------------</td>
<td>---------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Rocky Mountain maple</td>
<td>Silty-loamy 20</td>
<td>(Not)</td>
<td>Found on mesic slopes and along streams from 4,000 to 10,000 ft. elevation. Important to wildlife for cover and forage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandstone scablandsite</td>
<td>Sandy to clay 11</td>
<td>(Not)</td>
<td>Moderately drought-tolerant. Long-lived. Prefers upland sites and dunes up to 5,000 ft. Used for cover and forage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cupleaf mustard mustang</td>
<td>Silty-loamy 11</td>
<td>(Not)</td>
<td>Adapted to dry, shallow soil conditions. Prefers dunes from 2,000 to 5,000 ft. elevation. Important to wildlife for cover and forage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellowroot* (Poa x repens)</td>
<td>Sandy to clay-locamy 15</td>
<td>(Not)</td>
<td>Drought-tolerant. Moderate use of mustangroot. Prefers upland sites and dunes from 2,000 to 5,000 ft. Important to wildlife for cover and forage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Huckleberry* (Gaylussacia baccata)</td>
<td>Silty-loamy 12-18</td>
<td>(Not)</td>
<td>Blue huckleberry. (L. montana and m. huckleberry (L. montana) Important to wildlife for cover and forage.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Adapted to saline and alkaline soils. 2. Requires wetland habitats, but prefers wet areas during critical seasons. 3. Seeding rate for wetlands, forbs and shrubs are included in the list of recommended values in a separate companion table. 4. See Nep, "California wetlands," p. 139.

Revegetation Guidelines for Western Montana

35
<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Moist, warm site</th>
<th>Potential semi-succulent advantages over high-moisture sites; site is mostly composed of natural grasses.</th>
<th>Core grasses are blue-grama, bluebunch, and big bluestem.</th>
<th>Pure seed FLD (seed/kg)</th>
<th>Rainfall (mm)</th>
<th>Seed yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Grass or grasslike species</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bluebunch wheatgrass</td>
<td>12</td>
<td>25</td>
<td>10</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Big bluestem</td>
<td>12</td>
<td>25</td>
<td>10</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Bluebunch wheatgrass</td>
<td>12</td>
<td>25</td>
<td>10</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Big bluestem</td>
<td>3</td>
<td>12</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Canada bluegrass</td>
<td>15</td>
<td>25</td>
<td>10</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Big bluestem</td>
<td>3</td>
<td>12</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Botanical species** Thermophytic: pincushion, Douglas-fir, Ponderosa pine, or 2 or 3 other coniferous species. *Note: All other species are used for either cold- or high-temperature purposes.*

<table>
<thead>
<tr>
<th>Zone 2</th>
<th>Moist, warm site</th>
<th>Site is much more humid than dry-moist sites; site is mostly composed of natural grasses.</th>
<th>Core grasses are blue-grama, bluebunch, and big bluestem.</th>
<th>Pure seed FLD (seed/kg)</th>
<th>Rainfall (mm)</th>
<th>Seed yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Grass or grasslike species</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bluebunch wheatgrass</td>
<td>12</td>
<td>30</td>
<td>10</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Big bluestem</td>
<td>12</td>
<td>30</td>
<td>10</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Bluebunch wheatgrass</td>
<td>12</td>
<td>30</td>
<td>10</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Big bluestem</td>
<td>3</td>
<td>12</td>
<td>30</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Canada bluegrass</td>
<td>15</td>
<td>30</td>
<td>10</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Big bluestem</td>
<td>3</td>
<td>12</td>
<td>30</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Botanical species** Thermophytic: pincushion, Douglas-fir, Ponderosa pine, or 2 or 3 other coniferous species. *Note: All other species are used for either cold- or high-temperature purposes.*

---

* The addition of native seeds is recommended when farming open spaces of seminatural or undisturbed agricultural land. *Note: All other species are used for either cold- or high-temperature purposes.*

* Based on pure seed, typical yield for Canada bluegrass. *Note: All other species are used for either cold- or high-temperature purposes.*
apple and myrothamnus inosula. These should be added when topsoil is uniform or is altogether missing from roadbeds. Before construction, plan a topsoil salvage and replacement operation when roadside topsoil is healthy and nutritious weed-free.

After completion of roadside construction, application of seed may or may not be necessary depending on the amount of desired plant propagules in the replaced topsoil. Delayed application of seed is not advised given the likelihood of rapid nutritious weed establishment along roadbeds. When selecting plant materials, consider species' ability to adapt to the site, to rapidly establish and to self-perpetuate. Whenever practicable, select and distribute native species for ecological reasons (Harper-Lore 2000). Native grasses such as Idaho fescue (Festuca idahoensis), sheep fescue (F. ovina), sandberg bluegrass (Poa sandbergii), canby bluegrass (P. canbyi), and 'Norman' tufted hairgrass (Deschampsia cespitosa) are short-growing and can significantly reduce roadside mowing maintenance.

Also consider species' ability to control against soil erosion. Consider rhizomatous species with extensive root systems that are tolerant of roadside disturbance (Tyster et al. 1998). For instance, streambank and thickspike wheatgrass (Elymus lanceolatus spp. paucisulcis and spp. lanceolatus, respectively), both strongly rhizomatous with excellent seedling vigor, are frequently used for erosion control. Blue wildrye (Elymus glaucus) is a native perennial bunchgrass highly desirable for use in erosion control. However, these species are not short-growing and may require mowing maintenance.

When revegetating roadbeds it is difficult to recreate a native community in its entirety. Still, incorporating key species within vegetation types appropriate to the site is recommended. Morrison (2000) states that dominant, prevalent (i.e., typically occurring most abundantly), and "visual estover (i.e., having some unique, visually important trait within the community)" species should be included. Selected native forbs that perform well along roadbeds include Pacific aster (Aster chilensis), lance-leaved and plains coreopsis (Coreopsis lanceolata and C. tinctoria), purple coneflowers (Echinacea purpurea), Drummond phlox (Phlox drummondii), and purple verbena (Verbena stricta). Implementing integrated roadside vegetation management practices that favor the seeded species is essential to long-term roadside revegetation success.

2. Quickly reestablish vegetation to minimize erosion

Sloped landscapes and drainages should be seeded with soil-stabilizing species to minimize erosion and sedimentation; such seeding often follows wildfires. Quick-establishing annuals can provide immediate protection, but only for a year. Grasses and grasslike plants that reproduce through rhizomes are ideal for erosion control because of their extensive networks of soil-

Design a seed mix
stabilizing underground stems. 'Crimson' thickspike wheatgrass, a native rhizomatous cultivar that has very strong seeding vigor, is good for site stabilization. Blue wildrye is a native, cool-season bunchgrass commonly used in erosion-control seedings where slope or site stabilization is needed. Pacific aster, Rocky Mountain beeplant (Conospermum irenudum), purple coneflower, yellow and white evening primrose (Oenothera biennis and O. pallida), 'Bandera' Rocky Mountain penstemon (Penstemon strictus), and lacy phacelia (Phacelia tanacetifolia) are nativeforbs that perform well in disturbed areas and as erosion control species. 'Ephiriam' crested wheatgrass (Agropyron cristatum), a non-native bunchgrass, is a variety selected for its rhizomatous growth habit. This wheatgrass is well suited for soil stabilization, but its use in natural areas is not advised given its aggressive and invasive characteristics. Grass-like plants such as sedges (Carex spp.), spike rushes (Eleocharis spp.), rushes (Juncus spp.), bulrushes (Scirpus spp.) and cattails (Typha latifolia) are helpful for erosion control in riparian areas.

See table 2, pp. 22–25, and table 3, pp. 26–29, for other recommended species characterized by soil-stabilizing growth forms.

Quick establishment is critical when selecting species to minimize soil erosion. Annual ryegrass (Lolium multiflorum) or small grains establish very quickly to provide rapid protection and are non-persisting. Regrow and triticate are sterile, hybrid crosses that reduce wind and water erosion and are also quick establishing and non-persisting. Canada wildrye (Elymus canadensis) is a native cool-season perennial bunchgrass that is often included in seed mixtures for its rapid establishment of protective cover. Comfort and Wiertzim (2000) recommend slender wheatgrass (Elymus elymoides ssp. elymoides), a quick-establishing native bunchgrass, at 20 to 40 percent of the seed mix in wildlife-affected cases. Winter wheat (Triticum aestivum) is a good choice for protection and cover into the spring but can be moderately competitive to establishing perennials.

3. Establish species that can minimize various weed invasion or reestablishment

An effective seed mix should avoid niche overlap and contain a functional diversity of aggressive, quick-establishing grasses and forbs that can occupy available niches. (Do not include forbs if broadcast treatment of broadleaf herbicides is anticipated.) Carpinelli (2000) found that a diverse, well-established plant community might better resist weed invasion than a less diverse community. Pockney (2002) states that enhancing forb functional group diversity, or enhancing the number of functional groups, might preempt resources, thus making resources less...
available to an invader. And Pokorny (2002) found that spotted knapweed performed best at sites with low levels of functional group diversity, especially when shallow- and deep-rooted native forbs were absent. This demonstrates that sites with a high functional diversity of native forbs are most competitive with spotted knapweed and most likely to resist invasion and establishment. It is highly recommended that the native forb component of a plant community be protected and enhanced to resist weeds and maintain ecosystem stability. Once removed, this critical feature of plant communities is difficult and expensive to reestablish. Careful weed management should aim to preserve native forbs.

For a plant community to be “weed-resistant,” it must effectively and completely utilize resources temporally and spatially. Designing a seed mix that includes shallow- and deep-rooted forbs and grasses that grow both early and late in the year will maximize niche occupation in time and soil profile space. Cool-season species initiate growth in late winter. In early spring, these species use soil resources available in the upper soil profile and begin seed production in early summer. Selected native cool season grasses include thinskrip wheatsgrass, slender wheatsgrass, western wheatsgrass (Pseudoroegneria spicata), sandberg bluegrass and Canada wildrye. These grasses are competitive with weeds and in fact may prove good weed suppressors.

Idaho fescue and ‘Covar’ sheep fescue are native drought-tolerant cool-season bunchgrasses that are aggressive and strongly competitive once established in mature stands. Non-native grasses that are highly competitive with weeds include ‘Luna’ pubescent wheatgrass (Elytrigia intermedia ssp. trichophorum), hard fescue (Festuca longifolia) and, owing to its long season of growth and extensive root system, ‘Boloticky’ Russian wildrye. Solid stands of meadow brome (Bromus inermis), a non-native bunchgrass, are relatively resistant to weeds. Competitive native forbs suitable for revegetation include ‘Appa’ blue flax (Linum lewisii), white yarrow (Achillea millefolium), Maximilian sunflower (Helianthus maximiliani), blanketflower (Gaillardia aristata), and sunflower (Helianthus angustifolius). Lacy phacelia is an aggressive native annual that may have good competitive abilities. Pokorny (2002) states that gayfeather (Liatris punctata), a native forb, is a very strong competitor with spotted knapweed; check with seed suppliers on the availability of this species. Numerous other native forbs are available and suitable for revegetation efforts.

Incorporating deep-rooted shrubs such as sagebrush, rabbitbrush (Chrysothamnus spp.), bitterbrush or ‘Wyana’ fourwing saltbush in the seed mix or as young plants can further make use of resources from the lower soil profile throughout and late in the growing season. Furthermore, the addition of shrubs can enhance establishment of understory species by increasing water availability, infiltration rates and water-holding capacities, and soil fertility and seedbanks. Shrubs also increase establishment of understory species by concentrating nutrients...
4. Restore a healthy plant community

Weed-infested sites alter the structure, organization and function of ecologic systems (Olson 1999). The development of a healthy plant community comprising functionally diverse species is the key to sustainable invasive weed management, while meeting other land use objectives such as forage production, wildlife habitat development, or recreational land maintenance (Stichy et al. 1996).

The development of a healthy plant community involves long-term management that includes steady removal of individual weeds with replacement by desired plants. This replacement can occur via natural revegetation when desired vegetation cover and propagules are adequate within the infestation, or through artificial revegetation efforts. Species selection to restore a desired or healthy plant community should follow recommendations in the previous section and other recommendations specific to the site’s intended use. * * *

It is imperative to protect the remnant native forb component within the weed-infested site during weed management. This may be difficult to do, for often the preferred choice of infestation management is broadcast herbicide treatments that often injure or permanently damage remnant native forbs. Instead, site-specific methods such as herbicide spot treatments should be developed and carefully employed to protect remnant forbs.

Forb protection within weed-infested sites is important not only because forbs are vital to ecosystem stability but because forbs have demonstrated strong competitive abilities against invasive weeds (Pikovský 2002) and may be key to successful long-term weed management.

After the development of a healthy plant community, long-term maintenance that favors the seeded species will be needed. The desired grass component should be managed to encourage strong vigor and growth, such as by avoiding heavy grazing practices, and the forb component should be managed to encourage the highest levels of diversity such as through periodic prescribed burning.

Site Characteristics

Once species have been selected to meet revegetation goals and management objectives, site characteristics such as soil attributes and the precipitation, soil moisture, temperature, and elevation can confirm species selection.

Soil attributes

Revegetation Guidelines for Western Montana
Soil texture, which is determined by the size of the particles that comprise the soil, is an important characteristic that can direct species selection. Most seeded species prefer medium- to fine-textured soils. However, Indian ricegrass, a highly drought-tolerant native bunchgrass, is well adapted to sandy soils, and western wheatgrass, a native rhizomatous grass, does well on heavy clay soils. Optimal soil texture is usually loam comprising 45 percent sand, 35 percent silt, and 20 percent clay. (See figure 2, right. And see the text box below the figure to determine your soil type. For large or challenging projects, consider obtaining a soil survey map from your local USDA Natural Resources Conservation Service field office.)

Testing the chemical properties of soil can be helpful in directing or confirming species selection and in suggesting any soil amendments. And testing can indicate the suitability of a given soil for plant survival and growth.

If you're planning a challenging revegetation project, you should test the soil for:

1) pH: The optimal range is 6.5 to 7.5. Seeded species adapted to highly acidic (pH <6) or highly alkaline (pH >8.4) soils should be used instead of attempting to amend the soil with additions of sulfur, peat, lime, or fertilizer. Grasses, grass-like species, forbs, and shrubs adapted to saline-alkaline soils are listed in tables 2, 3, and 4.

2) Electrical conductivity. This is a measure of soil salinity;

Soil attributes

Fig. 2. Soil natural triangle illustrating the range in composition of sand, silt, and clay for each soil texture class. The dashed line depicts a loam soil that has 45% sand, 35% silt, and 20% clay content.

Manual testing

You can roughly estimate the approximate amount of sand, silt, and clay in a soil by a simple procedure called “manual testing.” Hold a handful of moist soil in your hand. If the soil feels gritty and crumbly, it is sand. If the soil feels powdery, it is silt. If the soil feels doughy and sticky, it is clay.
3. Sodium absorption ratio. This is the proportion of sodium ions to the concentration of calcium plus magnesium ions in the saturation extract; optimum is <5. When SAR sites above 12, serious physical soil problems arise and plants have difficulty absorbing water.

4. Organic matter. This is a measurement of the percent organic material and humus in the soil. Optimum is >3%. Organic matter increases soil porosity, infiltration, water-holding capacity and nutrient reserves, and improves soil structure. The addition of organic matter such as compost can increase soil microorganism development and thereby enhance the establishment of seedling species.

Precipitation, soil moisture, temperature, and elevation of the site

Seeded species should be adapted to the precipitation and moisture level of the site. Temperature zones and elevation of the site should also be addressed. See table 5, p. 30, for recommended grass species by western Montana zone.

Wisconsin weeds, seeds collected from the local landscape, are locally adapted and can have excellent establishment and long-term resiliency. But large quan-tities must be collected to offset the disadvantages of low seed viability. Custom-collecting is commercially available, and may be indicated for large projects when site-specific seed is desired or when preferred species are not available in the marketplace. Seeds can be collected and used immediately or may be increased through cultivation—"grown out" to meet future needs.

Numerous species perform well on rich, high soil moisture, and riparian/wetland sites as stream bottoms or wet meadows that are often grazed by at least part of each growing season. Bent-leaf willow (Salix eriocephala) is a native adapted to a wide variety of soils that are slightly alkaline or wet or occur in precipitation zones greater than 18 inches. Among other suitable natives are wheatgrass, western wheatgrass, tufted hairgrass, and red fescue. Orchardgrass (Dactylis glomerata), field brome and tall fescue, although not native, are often recommended for irrigated pastures in Montana. Smooth brome is another non-native that is less frequently recommended for irrigated pastures. Other non-native grasses that perform well in irrigated pastures are listed in table 6, pp. 26-29.

Native sedges, siskuikushus, bluebells, goldenbush, and cattails are grass-like species used extensively in riparian and wetland reclamation projects because of their aggressive root systems and wildlife habitat values. Numerous native grasses, forbs, and shrubs are available for wetland/riparian revegetation projects; see tables 2 and 4. Planting greenhouse-grown plugs has shown higher establishment over seeding or planting wildings—plugs collected from wild populations (Hiscock and Solet 1995). Plugs
Native vs. non-native species selection

Many land managers interested in wide adaptability, ease establishment, forage production and competitiveness with noxious weeds are shifting from seeding such introduced grasses as crested wheatgrass to reestablishing native species to ensure or maintain native ecosystem genetics and ecological integrity. This shift is based on social values that are changing as a result of advances in ecological knowledge.

The benefits of using natives include—

- **Erosion control** Many native grasses and forbs have rhizomes or deep and fibrous root systems that help prevent soil erosion. Blue wildrye can provide quick erosion control. Streambank and thickspike wheatgrass, both strongly rhizomatous grasses with excellent seeding vigor, are also used for erosion control. 'Tandera' Rocky Mountain pennycress, developed for its fibrous root system, is often included in reclamation seed mixes for its ability to control erosion.

- **Vegetation management** Short-growing native grasses such as Idaho fescue, sandberg bluegrass, early bluegrass, and 'Nortex' turf fescue grass reduce roadside mowing maintenance.

- **Ecology and aesthetics** Native plants can maintain ecological stability and establish a more natural setting. In a Glacier National Park study, Tyler et al. (1998) found the use of natives for roadside revegetation to be preferable for ecological and aesthetic reasons.

- **Resiliency** Natives represent a genetic product of an environment and are adapted to the means and extremes of an area. Natives can maintain excellent performance under a variety of conditions and demonstrate fewer boom-or-bust responses to environmental extremes than some introduced species (Brown and Wimmer 1984). For instance, non-native crested wheatgrass can perform well in an average rainfall year, but drought in combination with other environmental conditions severely limits its performance. Many native grasses and forbs—see table 2, pp. 22-25, and table 4, pp. 30-35—are resilient to drought, and replacement plantings should be made.

- **Improved water quality** Fertilizers and other agricultural runoff into surface water is greater with nod or common turf than from deep-rooted native grasses, such as slender wheatgrass.

Many non-native grasses are competitive with noxious weeds. However, selected native grass species can also be effective competitors. Highseal native bunchgrasses such as Idaho fescue and 'Lovel' sheep fescue compete well with noxious weeds and such invasive grasses as cheatgrass on degraded sites. Thackspike wheatgrass, slender wheatgrass, western wheatgrass, and Canada wildrye are also competitive.

Adapted in part from Harper-Lincoln, 2000
Step 7

should be planted during autumn, when heat, light and water stress are greatest. Broadcast seeding of wetland/riparian areas is used primarily to increase overall species diversity. Following seed broadcast, avoid covering seeds with soil; light and heat are needed for proper germination.

ECOTYPES

Many plants that have a large range vary considerably in height, growth habits, leaf characteristics and reproductive habits. Plants of the same species that display such variations are grouped into local ecological units associated with habitat differences. These local ecological plant groups are known as ecotypes. In the early stages of natural development these ecotypes are identified by the plant characters that come with breeding to the desired character. In practice, ecotypes are considered best adapted to areas no farther than 200 miles from their origin or point of collection.

Revegetation Guidelines for Western Montana
Step 8
Assist establishment

Seeding establishment is the most critical phase of revegetation (James 1992). However, variations in soil, site exposure and climate can hinder this vulnerable phase. Failures to establish are usually caused by a combination of factors: the most important are insufficient soil moisture and intense weed competition (Jacobs et al. 1990). Schoenfeldt et al. (1992) stated that early revegetation success is a function more of moisture than of soil nutrient availability, and Masters et al. (1990) stated that weed interference was the primary concern to successful establishment of native plants.

Enhancing establishment can increase revegetation success. Avenues of enhancing establishment include:

a) Using species adapted to local site conditions and using high-quality, certified seed.
b) Reducing or eliminating weed interference through herbicide treatments or early-seed cover crops that work to reduce the availability of soil nitrogen.
c) Inoculating seed, nursery stock locally collected or salvaged legumes with proper bacteria to ensure maximum

nitrogen fixation that can contribute to a healthy nitrogen cycle. This will improve phosphorus uptake, water transport, drought tolerance and resistance to pathogens, and by increasing off-season quality will contribute to long-term reproductive success and fitness of seeded species.
d) Heightening seedling survival by preparing the seedbed before and after broadcast seeding and lightly packing the soil. (Consider the application of hydromulch following broadcast seeding to enhance establishment.) Avoid covering wetland/riparian species with soil; light is needed for proper germination. (Alternatively, if the site is accessible to equipment, place seeds at the proper depth using a 10-cm drill.)
e) Planting plugs to establish wetland/riparian grassland species. Huq (1994) found that revegetation with planted plugs had higher establishment rates and spread faster and further as compared with revegetation with seeds or seedlings.
f) Using a land inverter to form depressions in the soil; these depressions retain moisture at the surface longer than smooth soil surfaces. Soil depressions create good conditions for soil coverage of broadcast seeds. Their sides tough off and trap wind-blown particles.
g) Increasing seeding rates to:

- Enhance desired species competitive interaction with

Assist establishment
aneous weeds. For instance, Vlagala et al. (1997) found that increasing intermediate wheatgrass densities removed the effect of spotted knapweed on intermediate wheatgrass where interspecific interference occurred.

- Increase the likelihood that an adequate amount of broadcast seeds find safe sites (Sheley et al. 1999), and
- Compensate for a lack of understanding of plant-plant relationships (Vallentine 1989).

b) Adding small amounts of water temporarily to encourage establishment—but only in cases when natural precipitation has proved inadequate. (However, an initial watering is recommended after transplanting during the growing season.) Be aware that frequent watering may well result in poor plant adaptation and only short-term success followed by failure once supplemental water is withdrawn. In one study, supplemental watering stimulated germination but had little lasting, long-term effect (Padgett 2000). Consider using commercial water-holding polymers and similar products during the establishment period to provide young plants with moisture.

c) Deferring grazing by means of fencing or herding until vegetation reaches establishment, typically after two growing seasons. If palatable slow-maturing shrubs are recovering, do not graze until the shrubs are able to produce viable seeds.

**Step 8**

Treating seeds may also enhance the establishment phase of revegetation. Consider the following seed treatments when appropriate.

**Seed priming** initiates the germination process, allows it to continue to a certain point, then suspends it. The primed seed is then ready to continue germination in the field when conditions are favorable. Seed priming is helpful in revegetation of weed-infested sites since the first seedling to capture resources has a competitive advantage (Harper 1980).

**Seed fungicide** protects seeds from numerous soil-borne organisms. Consider this treatment in moist environments.

**Seed stratification.** Cold stratification "softens" seeds into germination mode by mimicking the winter environmental conditions the seeds would be subject to in the natural environment. Many upland species such as beardless wildrye and Indian rye grass need cold stratification to reduce seed dormancy and improve germination. Most wetland/priparian seeds should be cold-stratified in a proper medium, usually distilled water and sphagnum moss, for 30 days at 32–30°F.

**Seed scarification** Seeds with considerable dormancy—Indian rye grass, beardless wildrye, sweetwetch (Hesperanum forsetii), prairie clover (Trifolium pradticum spp.) and sumac (Rhus spp.) among them—benefit from acid or mechanical scarification of the seed coat. This treatment greatly improves germination.

**Seed coating** Seeds coated with such growth regulators as cytokinin or diatomaceous earth can improve seedling establish-
Mulching

Providing an immediate mulch cover can protect soil and seeds from erosion by wind and water, conserve soil moisture from the effects of wind and sun, and moderate soil temperatures. The following mulches can enhance germination and establishment:

Hay mulch. Native certified weed-free hay is a beneficial mulch that contains a small amount of nitrogen from leaves, flowers and seed heads. Native hay can also contain seeds of native plants if harvested with mature seeds present.

McGinnes (1987) found that volunteer stands developed in areas where hay mulch contained a large amount of seed. As a result, more diverse communities can be developed on sites mulched with native hay than on sites mulched with other products. Native hay harvested can typically include needle-and-thread grass, western wheatgrass and bluebunch wheatgrass.

When attempting to seed needle-and-thread grass, the long awns can prove problematic. However, these long awns become useful appendages in hay mulches by working the seed into the ground, improving germination (Smolik et al. 1990). Mulches are used for short-term protection on moderate (0.1) to flat slopes. Use enough hay to completely cover the soil. To avoid losing mulch to the wind, if it is still pliable it can be crimped into the soil to avoid excessive breakage or transplanted short-term by livestock. Or an organic tackifier, a glue that breaks down into natural byproducts, can be applied.

Suitable mulch crops: Sterile forage sorghum, sudangrass (Sorghum sudanense) or forage millet are planted the growing season prior to permanent seeding. After crop maturation, native seeds are sown into the residual standing dead material. Standing mulch keeps snow, improving soil moisture during the critical germination phase.

Cover or companion crops: Fast-growing, non-persistent annuals or short-lived native perennials such as mountain bristle, slender wheatgrass, Canada wildrye and blue wildrye, or non-native perennial ryegrass (Lolium perenne) are seeded with perennial grasses to protect soil and the young, slower-establishing perennial seeded grasses. Sterile hybrids such as Regreen, a cross between common wheat and tall wheatgrass, and Triticate, a cross between common wheat and cereal rye (Triticosecale rupicola), were developed specifically for use as cover or companion crops. Regreen and Triticate establish rapidly, do not persist or reseed into successive years and are completely out-competed by the seeded species. Triticate is often used as a companion crop when maximum forage is desired while slower-developing perennials establish. Avoid using cereal rye as a cover crop; it is very competitive and may aggressively spread to surrounding sites.

Hydromulch (hydraulic mulch) Hydromulch is virgin
wood fibers or recycled paper mixed into a water slurry and sprayed onto the ground. Long wood fibers interwine with one another to form a rigid bond. Excellent erosion protection is provided when hydromulch is used with a tackifier. Recycled paper mulch will decompose quickly and provide good protection on relatively flat areas. It is particularly useful in conjunction with quick-establishing vegetation or following broadcast seeding.

Bonded fiber matrix. Bonded fiber matrix is a sprayed-on mat consisting of a continuous layer of elongated fiber strands held together by a water-resistant bonding agent. A continuous cover is needed to create the integrated shell. Hire a certified contractor who knows how to apply the material appropriately; if it is applied too thickly it can prevent penetration of seedling shoots.

Erosion control blankets. Usually composed of woven organic material such as straw or coir. These blankets are designed so that seed germinate and to permit stems to grow through and above the mat. As the fabric ages it becomes incorporated into the soil and decomposes. The erosion-control coir mat is replaced by established vegetation. Mats are expensive but highly effective, and for steep slopes (3:1 and greater) that need long-term protection they are sometimes the only choice.

Conditions for successful establishment
Successful establishment cannot require all of the following conditions:
- Seed placed in favorable microclimate
- Precipitation adequate to stimulate germination
- Reforestation precipitation for seedling establishment
- Low levels of humidity
- Absence of competition during establishment

Adapted from Wrex (2016)

Revegetation Guidelines for Western Montana
Step 9
Determine a seeding method

The most common seeding methods are drilling, broadcast seeding, imprecision, lay-nudge seeding, hydrosowing, "kicked" plugging, and spiggling. Plugging is used to establish wetland/riparian plantings. Spiggling is used in saline-alkaline soils with rhizomes as plant propagules. Which seeding method to deploy depends on site accessibility and terrain and method characteristics.

Drill seeding

A non-rocky site that is accessible to equipment should be seeded with a no-till drill. This is a tractor-pulled machine that opens a furrow in the soil, drops seeds in the furrow at a specified rate and depth, and rolls the furrow closed. This method is preferred since seed depth and seed row are closely controlled and the seed-soil contact is high, directly enhancing seedling establishment and germination success. Ideal seedling depths are about 1/4 inch for small seeds and about 1/2 to 1/2 inches for large seeds. Seeding depth varies with site characteristics that influence soil moisture, chiefly among them are soil texture, site exposure, and aspect. (For specific-depth recommendations, contact your local Extension office or USDA Natural Resources Conservation Service or Conservation District field office.)

Although drill seeding can enhance seedling establishment, some shortcomings should be recognized:

- The plants that germinate develop in rows that resemble a crop rather than a native plant community.
- Wetland/riparian species require plenty of light and heat to germinate. These plants should not be drill-seeded. Their seeds need to remain on top of a moist soil surface, as they will if broadcast-seeded.
- Long, narrow seeds such as those of smooth brome are difficult to plant because they become bridged within the drill.
- Because some species require shallow placement in the soil while others require deeper placement, two separate seeding operations may be needed when planting seed mixes.
- Seeds of various sizes will separate in the seed container prior to soil deposit. Very small seeds vibrate to the bottom of the seed box and fall from the box faster than larger seeds. Adding a carrier such as sand, cracked corn or rice hulls can mitigate the size or weight segregation of seeds by dampen-
ing vibrations in the seed box. Adding a carrier also controls the flow of problematic seeds with wing swan (like needle-and-thread grain) or light and hairy or fluffy seeds (like creeping fennel or meadow fennel) [Alphonse et al.]. These seeds form large bunches that interweave with the bulk of individual seeds from the boxes into the seeding tube (Muschower 1994).

- Drill furrows cut from soil erosion from water flow unless seeding is performed along slope contours.

**Broadcast seeding**

Broadcasting is a commonly used seeding method, it is commonly utilized on steep, rocky or remote sites that are inaccessible to equipment. Aircraft can seed inaccessible areas such as those burned by wildfires. Small areas can be broadcast-seeded with a hand spreader; commercial spreaders can seed larger areas.

Seedbed preparation is recommended prior to broadcasting. On accessible sites, dragging small chains or harrowing and raking can roughen and loosen the soil surface. Roughening creates seed-safe sites, ensuring proper seed placement for enhanced germination and establishment. Roughen the soil surface again following seeding and, if possible, lightly roll or pack the soil.

If seedbed preparation is not feasible, doubling or tripling the broadcast seeding rate appropriate for drill seeding or plowed-ground seeding will be necessary to make sure that an adequate amount of seed finds safe sites for germination.

**Broadcast seeding of wetland/watershed species** is used not a primary means of reestablishing but as a method to increase overall species diversity. When broadcast seeding, do not cover or pack the seeds with soil; wetland plant seeds need plenty of heat and light for good germination. Consider planting plugs of wetland/watershed species as the primary reestablishment method to ensure long-term success.

**Hydromulching**

Hydromulching is a form of broadcast seeding in which the seeds are dispersed in a liquid under pressure. The hydromulcher consists of a water tanker with a special pump and agitation device to apply the seed under pressure in water that may include mulch or other additives. In some cases, the seed-germination and establishment results of hydromulching are less satisfactory than drill or broadcast seeding since the seed does not always make good seed-to-soil contact. Even so, hydromulching is usually the only practical method for seeding slopes > 3:1 or steeper.

The addition of mulch can enhance soil protection. Alabados (2000) found that hydromulching with the application of slurry with humic acids or both reduced soil runoff and soil loss up to 98.5 percent on two 40 percent anthropogenic (that is, severely man-modified) steep slopes. An increase in the...

*Revegetation Guidelines for Western Montana*
density of plant cover was observed seven months after the hydronic treatments.

Land imprinting

Imprinting uses heavy tamped rollers to make impressions in the soil surface that aid water infiltration and soil aeration. The imprint work as small precipitation catch-basins that enhance water accumulation for improved seed germination. On accessible sites, imprinting can be used in conjunction with broadcast seeding. Seed can be broadcast in front of the imprinter and pressed firmly into contact with the soil. Small seeds are typically broadcast behind the imprinter so that splash erosion covers seed in the depressions without burying them too deeply in the soil. Imprinters filled with seed burs can be used above seeding devices.

Hay mulch seeding

Hay mulch seeding entails spreading seed-containing hay over a prepared seedbed. Hay mulch seeding is useful since the hay is both the seeding method and mulch that prevents soil erosion, conserves moisture and moderates soil temperatures. However, since each species produces hay at a slightly different time, many species can be sown from or underrepresented in any given hay harvest. Hay should be cut when the important species are at an optimal stage of maturity and spread during the optimal seeding time for the dominant or preferred species within the hay. Spreading hay by hand is practicable on small sites, but hoppers or trailers that shred and apply the hay are better for larger sites. To avoid loss to wind, hay can be crimped into the soil with machinery, pushed into the soil by the trampling hooves of livestock, or held down upon the soil with an organic tackifier.

"Island" planting

Planting nursery stock selected for the environmental, physical and chemical characteristics of a site can complement seeding and increase overall revegetation success through rapid plant establishment. Planting survivor stock circumvents the susceptible and critical seed germination and establishment stages. Purchase stock can be costly. However, planting fewer individuals in "islands" where control, established stands of plants can reproduce and eventually spread throughout the area can reduce costs. The effects of such islands will be long-term; an immediate increase in the number of nonseeded species resulting from this practice should not be anticipated.

Island-planted shrubs as overstory plantings can complement a revegetated site. The ability of shrubs to increase water availability through moisture interception, enhance soil fertility, and...
reduce evapotranspiration, increase nutrient cycling, add organic matter to the soil, and improve soil structure (West 1989) increases establishment of understory species.

**Planting**

Establishing wetland/savanna plants from seed is usually difficult because site hydrology must be carefully controlled and precise amounts of heat, light, and water are needed. Planting plugs skirts the susceptible and critical seed germination and establishment stage. Hong and Sellars (1995) state that planting plugs to recreate wetland areas is preferred in broadcast-seeding or collecting wildlings (see Step 1). Transplanting, p. 55). Greenhouse-grown plugs of wetland/savanna grasses, grass-like species and herbs and shrubs should be planted on 18- to 24-inch centers (Hong 2000), which works out to about 11,000 plugs per acre (Comfort and Wiemau 2000). Over time, the plugs will spread out into the unplanted area.

In Idaho, plugs have been successfully planted from April through late October. Spring planting is generally preferred over fall planting since spring-planted plugs will have a longer establishment period. Fall planting may result in lower establishment success because of the shorter growing season and damage from frost heaving (Hong 2000). Wetland/savanna plants favor warm temperatures, long days and lots of water. In Montana, June may be the best time to plant plugs.

Control of site hydrology is important during planting and establishment. A detailed description is provided in Harvesting, Propagating, and Planning Wetland Plants (Hong 2000). Riparian/Wetland Project Information Series No. 14, available from USDA Natural Resources Conservation Service field offices across the nation.

**Spraying**

Spraying is the planting of rhizomes at a depth of three to four inches. Specialized equipment for digging and planting sprigs is commercially available. Plants can be established by spraying at slightly higher soil moisture levels than by seedling because the rhizomes are more salt-tolerant than seedlings and are placed below the highest concentration of salt on the soil surface (USDA 1996). Once established, rhizomatous grasses will continue to spread. The availability of a suitable water and proper equipment are the main limitations on this method.

Renovation Guidelines for Western Montana
Step 10
Calculate seeding rate

Depending on the species, seeding rates are typically 20 to 50 viable seeds per square foot. The actual rates vary depending on many factors, among them weed interference, known differences in seeding vigor, site conditions and the components of a mix. When a species is used as a component of a mix, adjust its percent of mix desired. Wetland/dune species as plugs should be planted on 10- to 24-inch centers (Sieg 2000). Use the recommended amount of pure live seed (PLS) found in tables 2 through 5. Consider increasing rates 30 percent for irrigated sites, doubling rates when seeding a severely burned area (80 seeds per square foot for perennial grasses), and doubling or trebling rates when seeding to compete with excessive weeds or if broadcast- or hydroseeding. Inclement seeding rates add expense to a project, but this good investment may yield to ensure establishment and long-term regeneration success.

When designing a seed mix, calculate separately the number of pounds of PLS of each species and then divide by the number of species in the mixture. Then take the pounds per acre and multiply by the total acres to be seeded.

For a mix of four grasses to be seeded on ten acres, for example, divide the pounds per acre for each species by 4 and then multiply by 10. (For dense ryegrass: 12 lbs per acre/4 species x 10 acres = 30 lbs.) Common seeding rates for timothy are 8-10 pounds PLS per acre when seeded alone and 4-5 pounds PLS per acre when seeded with another species, usually a legume in nature.

Pure live seed is a measure that describes the percentage of a quantity of seed that will germinate: PLS equals the percent purity times percent germination. Multiplying the purity percentage by the percentage of total viable seed (germination plus dormant), then divide by 100 to calculate the PLS content of a given seed lot. Because the PLS measurement factors in quality, purchasers can compare the quality and value of different seed lots.

Consider this example (adapted from Granite Seed Company [2000] and used here with permission):

<table>
<thead>
<tr>
<th>Seed lot A</th>
<th>Seed lot B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost/lb.</td>
<td>$1</td>
</tr>
<tr>
<td>Percent purity</td>
<td>75</td>
</tr>
<tr>
<td>Percent germination</td>
<td>60</td>
</tr>
<tr>
<td>Percent PLS</td>
<td>45</td>
</tr>
</tbody>
</table>

53
Seed lot A might appear to be the better value because its cost is only $1 per bulk pound, whereas the cost for seed lot B is $1.50 per bulk pound. However, the quality of seed lot A is far inferior to seed lot B.

To properly compare the value, a purchaser would calculate the cost per PLS pound by dividing the bulk cost by the percent PLS (PLS cost = bulk cost x 100/percent PLS). The calculation shows that seed lot B is the better value at $1.57 per PLS pound; seed lot A costs $2.22 per PLS pound.

Precise ordering of seed based on PLS allows purchasers to get full value for the money they spend on seed.

When designing a seed mix, the percent of each species desired in the mixture needs to be determined. Multiply the percent desired in the seed mix times the pounds of PLS recommended per acre to get the PLS mix per acre.

The following example, adapted from Haug (2003), shows the calculation of seeding rates for mixed seed:

**Determining Bulk Rate for Drill-Seeding**

Haug (2003) states that when seeding the recommended PLS seeding rate using a drill, the bulk rate of seeding needs to be determined since the material in the seed lot cannot be removed. To calculate pounds of bulk seeding per acre, divide pounds of PLS by the recommended rate per acre by dependent PLS.

For example, if the recommended seeding rate for Hycrest certified wheatgrass is 10 pounds PLS per acre and the PLS is calculated to be 80 percent, the bulk rate needed to seed the recommended PLS is determined thusly:

10 PLS/acre x 0.80 PLS = 12.5 lbs bulk seeding rate per acre

**Given**

Of the desired seed mix, 85% will be bluebunch wheatgrass. This lot of seed has a 90% PLS. The recommended seeding rate is 12 lbs. The remaining 15% of the mix will be small burnet. This lot of seed has an 85% PLS. The recommended seeding rate is 10 lbs. PLS per acre. Thus—

- Bluebunch 85% x 12 lbs. PLS/acre = 10.2 lbs. PLS/acre mixed
- Small burnet 15% x 10 lbs. PLS/acre = 3.0 lbs. PLS/acre mixed

**Determine**

Amount of bulk seed (mixed) per acre using the formula above

**Solution**

Bluebunch: 10.2 PLS/acre x 0.80 PLS = 11.3 lbs. bulk mixed/acre

Small burnet: 3.0 lbs. PLS/acre x 0.80 PLS = 3.5 lbs. bulk mixed/acre
Some plants tolerate transplanting better than others. Rough dune (Portulaca oleracea), a native beach shrub, can tolerate transplanting. Native plants growing in disturbed areas have been found to be particularly well suited for transplanting (Goodlet 1995). Native plants to consider include purple three-awn (Aristida purpurea), Pacific aster, Rocky Mountain bee plant, lance-leaved compass, sunflower and yellow and white evening primrose. Plots with taproots and extensive root systems are least likely to tolerate transplanting. To heighten transplantation success when performed during growing periods, water individuals at the time of transplanting and consider occasional and temporary short-term watering. Also consider adding compost during planting to reduce transplant shock and increase plant survival, especially in lower fertility, lighter, droughy soils (Atchue 2001).

Plants fewer individuals is islands where a central, established plot of plants can reproduce and eventually spread throughout the area can reduce the time and effort costs of transplanting salvaged or local native plants. Island-planted salvaged or locally collected shrubs can complement a revegetated site.

Such overseedy plantings may increase establishment of understory species. Call and Roundy (1994) summarized West (1989) in stating that shrubs can—
- Positively affect water availability by intercepting water from light rain and snow

Step 11

- Increase infiltration rate and water-holding capacity by improving soil structure through reducing raindrop impact and adding organic matter from litterfall
- Enhance soil fertility and seedbanks for plant establishment by caching wind-blown soil, seeds and mycorrhizal spores, and concentrating nutrients through absorption and fixation by roots; and
- Decrease understorey temperatures that reduce evapotranspiration and increase nutrient cycling when shrub canopies are present.

Transplanting wild wetland/riparian plants (i.e., willows) is often implemented, but planting plugs is preferred; as Hoag (1994) states, plugs have higher establishment rates and spread faster and further than transplanting or straight seeding. However, transplanting wetland plants, which can be done successfully because of their sturdy root systems, is a useful and viable revegetation method. When removing wetland plants, dig no more than 14 inches of plant material from a four-foot-twosquare-inch area and do not dig deeper than five or six inches (Hoag 2000). Leaving the soil on the removed plants ensures that the mycorrhizae remain intact, which increases establishment success. To avoid transporting weed seeds from collections made at weed-infested sites, wash the soil from plants and inoculate them with mycorrhizae, and to minimize shock, plant the collected plants as soon as possible.
Step 12
Determine the best time to revegetate

The right time to seed depends on the species being seeded and the soil moisture. Warm-season species are commonly seeded during late spring or early summer. Fall-dormant seedings are common with cool-season species or when mixtures of grass, legumes, forbs and shrubs are used (Brown and Wiener 1984). Dormant seedings should occur after the soil temperature has fallen below 55°F for a consistent one- to two-week period. This period is usually during late fall (i.e., late October and early November) just before the soil freezes, when temperatures and moisture remain low enough to prevent germination before the spring (Cash 2001). Dormant seedings are essential for many cool-season species that require cold stratification. Beardless wildryes, blue fescue and many other grass and forb species require cold, and Indian ricegrass needs exposure to at least 30 days of cold soil to meet its stratification requirements (Brown and Wiener 1984). When conditions are not adequate for a fall-dormant seeding, early spring seedings may capitalize on late snows and early rains. Plant wetland/riparian plugs during June, when warm temperatures, long days and adequate water prevail.

Soil texture can influence the timing of seeding. For instance, when seeding cool-season species on heavy- to medium-textured soils, consider a very early spring seeding. On medium- to light-textured soils, consider a late fall seeding (USDA 2000). Generally, a late fall-dormant seeding is best for all cool-season species regardless of soil moisture; the cold stratification requirement of many cool-season species will be satisfied during the winter months.

Late-summer planting—prior to mid-August—of cool-season species should only be done only if supplemental water is available from irrigation or as stored soil moisture. With irrigation, planting can occur from spring until mid-August; allow for emergence four to six weeks before first frost (Cash 2001).

Planting or transplanting tree and shrub seedlings should be done during fall or early spring dormancy to increase planting success. Seeding directly into the seed layer immediately after a fire is the best time to seed burned areas. Contact your county or tribal Extension office, an office of the USDA Natural Resources Conservation Service or a Conservation District office for recommendations on optimal seeding times specific to your site.
Avoid problems

The following specification tips can help prevent or mitigate common problems:

- Order uncommon seeds and plants early
- Require local origin seed and seedlings
- Don't plant seed too deep when using a conventional grass drill
- Don't skip weed control steps to save time on a project
Step 13

Monitor success

Proper site monitoring identifies problems that could prevent or interfere with a successful revegetation project. This cost-effective component can identify problems such as—

- Unexpected seasonal changes that shift species composition or abundance (see Appendix C, p. 69; for information on succession and successful revegetation)
  - The invasion of re-establishment of noxious weeds from restraint zones or from an existing seedbank
  - Preferential foraging by wildlife
  - Erosion that can damage plant materials and the soil base
  - Small areas of vegetation failure (repair with new seed or plants and mulch); and
  - Unfavorable moisture.

Monitoring can identify and rectify these problems in time to allow for successful revegetation. These problems can be partially prevented by—

- Reducing weed interference before, during, and after seeded species establishment.
- Removing weeds. The first year or two of a project may be entirely dedicated to weed removal if the site is moderately to heavily infested with noxious weeds.
- During and after establishment, hand-pulling or spot-spraying noxious weeds with herbicides to avoid damaging naturally occurring or seeded forbs.
- Providing temporary walls until seedlings are established when adequate precipitation does not occur. Then, if the species were properly matched to site conditions, the plants are on their own (Harper-Lore 2000).
- Erecting protective fencing to mitigate the threat of selective grazing by local wildlife; and
- Using a protective mulch to protect seeds, prevent soil erosion, and conserve soil moisture.

Monitoring can range from quick visual inspection to an in-depth study of species composition, distribution, and density. Monitoring frequency will depend on site conditions. For example, a site prone to low moisture, high erosion or weed invasions should be monitored frequently.
Long-term management

Long-term revegetation success requires continuous monitoring and evaluation for timely adjustments to maintain the developed plant community. Long-term maintenance includes proper and careful weed management such as frequently monitoring the site and the adjacent area to detect and eradicate new weeds early and thus avoid weed spread. Long-term maintenance also includes allowing seed to set and disperse to perpetuate and maintain stands. Evaluate management practices at least annually, and modify them when necessary.

If grazing is the intended use of the site, further management will be necessary. This includes implementing grazing practices that encourage seeded species growth and vigor to extend the productive life and economic returns of seeded pastures. Encouraging seeded species growth and vigor also limits resources for invasive weed establishment and growth. A grazing management plan should be designed—a plan that encourages desired species. For instance, Indian ricegrass is highly palatable and nutritious and regarded as very valuable winter forage. However, overgrazing has resulted in virtual elimination from many rangeland types (Sosulski et al. 1990). The following methods benefit desired plants, enhancing and promoting a healthy rangeland system:

- **Berm seeded pastures separately from native rangeland and seedings of different species or mixtures based on differences in maturity, palatability, and grazing tolerance among species.** For instance, Russian wildrye has excellent year-round palatability and nutrition and should be fenced to guard against overuse.

- **Implement multispecies grazing.** Domestic sheep assist in the successional process towards a perennial grass community by usually avoiding grasses and instead, applying grazing pressure on weeds. When domestic sheep are grazed with cattle, a grazing balance is facilitated. Glimp (1986) found that on moderately stocked rangelands, one ewe per cow could be added without reducing cattle production.

- **Defter grazing until seeded species are well established, usually after two growing seasons.** Bitterbrush seedlings should not be grazed until the plants reach a height of eight to ten inches, which usually takes three to four years.

*See Holowecz et al. (2000) for in-depth recommendations on proper grazing management.*
• Avoid heavy grazing by determining and implementing proper stocking rates and grass utilization levels. Heavy grazing slows growth and reduces grass vigor by affecting carbon fixation. Even aggressive-growing non-native grasses cannot tolerate close and continuous grazing. Such grazing puts the grazed plant at a great disadvantage in competing for resources with an ungrazed weed. In eastern Washington, Shelley et al. (1997) found that the establishment of diffuse knapweed (Centaurea diffusa) was enhanced only when defoliation of the native bluebunch wheatgrass exceeded 60 percent, suggesting that defoliation beyond this level reduced the grass competitiveness.

• Alter the season of use Avoid grazing the same places at the same time year after year.

• Beware close grazing Close grazing during fall green-up can be very damaging to all grass species. Avoid grazing cool-season grasses from early August (30-45 days prior to average first frost) until the first “killing” frost in mid-October—a frost with several successive days of temperatures around 25°F. This period of rest allows roots to replenish reservoirs for winter survival and early spring growth.

• Rotate livestock among pastures to allow plant recovery before re-grazing the pastures. Recovery time depends on the species, weather and soil fertility. Plants with abundant leaves remaining after grazing will recover more quickly than closely grazed plants. A minimum recovery period of 21 to 30 days is usually needed when growing conditions are optimal in spring. Recovery periods of two to three months may be required after grazing in summer or early fall (Holtzworth et al. 2000).

• Outline the movement of livestock throughout the year.

• Minimize bare ground by promoting plant litter accumulation to prevent weed seeds from reaching the soil surface.

Regular range monitoring should be undertaken to determine the efficacy of the grazing program in maintaining the desired plant community. Range monitoring includes but is not limited to detecting changes in desired plant cover and noting such surface conditions such as litter accumulation and exposed soil. To permit the making of any needed adjustments in a timely way, annual evaluations are essential.
Conclusion

Revegetation is helpful and often necessary for speeding natural recovery and mitigating or preventing soil erosion and serious weed establishment and growth. However, revegetation necessity should be based on the abundance of available plant propagules at the site. Revegetation is also helpful in cases where range management improvement is desired.

Numerous steps must be implemented in a thoughtful way to increase the likelihood of a successful revegetation project. Often these steps include planned events such as soil and vegetation salvage and replanting operations or the implementation of judicious weed management plans that encourage the preservation of native forbs for ecosystem stability and sustainable weed management. Successful revegetation also includes determining appropriate species based on revegetation goals, environmental conditions, and site characteristics and utilizing the most appropriate seeding method at the proper time. Soil amendments, seed treatments, and matching are used to assist seeded species establishment. Monitoring revegetated sites is necessary to quickly identify problems for timely correction. Long-term management of the site should favor the seeded species.
Nuisious weeds in Montana fall into three groups—Categories 1, 2 and 3.

**Category 1** noxious weeds are currently established and generally widespread in many counties of the state. These weeds are capable of rapid spread and render land unfit or greatly limit beneficial uses. Weeds in this category are the third-highest management priority in Montana.

- Goosehead (Chenopodium amarum)
- Needleleaf crabgrass (Digitaria ischaemum)
- Whitefooted goosefoot (Chenopodium album)
- Leafy spurge (Euphorbia esula)
- Russian knapweed (Arthrophytum sp.)
- Spotted knapweed (Centaurea maculosa)
- Diffuse knapweed (Centaurea spp.)
  - Foot

**Category 2** noxious weeds have recently been introduced into the state or are rapidly spreading from their current sites. These weeds are capable of rapid spread and invasion, rendering land unfit. They are the second-highest management priority in Montana.

- Dry wood (Solanum oranthera)
- Rainbow kochia complex (Bromus pinnatifidus, T. Isabeliae, S. avenaceus)
- Giant kochia complex or kochia
- Yautia (Actinidia deliciosa and hybrids)
- Tall mustard (Sinapsis arvensis)
- Nanny chaff (Sinapis arvensis)
- Tussock (Sedum spathulifolium)
- Orange hawkweed (Hieracium aurantiacum)

**Category 3** noxious weeds have not been detected in the state or are to be found only in small, scattered localized infestations. These weeds are known pests in nearby states, are capable of rapid spread, and render land unfit. They are the highest management priority in the state. As of January 2004, there were three such weeds:

- Yellow starthistle (Centaurea solstitialis)
- Red chamomile (Chamaemelum nobile)
- Common ragweed (Dowina ambigua)

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Roadside revegetation sometimes has but limited long-term success because many roadside sites have low fertility and depleted biological activity. Their poor nutrient cycling results in inadequate retention of natural or amended nutrients, reducing the establishment and persistence of vegetative stands (Classen and Zasada 1995).

A properly implemented topsoil salvage and replacement operation greatly enhances the long-term success of roadside vegetation remediations. Topsoil contains potentially valuable microorganisms, invertebrates and living plant propagules. Biological activity in this zone cycles soil nutrients and increases nutrient availability, aerates the soil, maintains soil structure, and increases soil water-holding capacity. Topsoil additions can serve as a source of nutrients and mycorrhizal inoculum for revegetation of biologically inactive and nutrient-poor construction fill materials. Reapplication of healthy topsoil that has been properly stored during construction enhances revegetation success and promotes establishment of a persistent vegetative cover. Classen and Zasada (1995) state that when the volume of topsoil is limited, concentrating topsoil in small pockets to slow increased retention of the biological activity of the soil is recommended, as opposed to spreading the topsoil thinly over the entire surface of the site. However, Redenius et al. (1997) found that after ten growing seasons a thin layer of topsoil (six inches) was sufficient for the establishment and continued productivity of vegetation at a northwest Colorado mine site. Deeper topsoil depths (12, 18 and 24 inches) were associated with a plant community dominated by grasses. Shallower topsoil depths supported plant communities diverse communities that had significantly greater forb production and shoot density.

Following construction completion, application of seed may or may not be necessary depending on the amount of desired plant propagules in the replaced topsoil. Given the likelihood of rapid non-native weed establishment, especially along roadsides, delay is not advised if seeding is needed. When selecting plant materials, consider the ability of the species to adapt to the site, rapidly establish and self-perpetuate. Also consider species abilities to produce extensive root systems that guard against soil erosion. Many rhizomatous species are tolerant of roadside disturbances (Tyer et al. 1998).

Whenever practicable, select and distribute native short-growing species, both for ecological reasons and to reduce long-
Appendix B
gem mowing maintenance (Harper, 2000).

Although it is hard to measure a native community in its entirety, incorporating key species within vegetation types appropriate to the site is recommended. Monson (2000) states that dominant species, prevalent species (i.e., species typically occurring most abundantly) and "virtual essence" species (i.e., species presenting a visually important trait within the community) should be included. As with any successful revegetation effort, vigilant monitoring to quickly identify invasive weeds and other problems for timely correction will be necessary. And integrated roadside vegetation management practices that favor the seeded species are essential.

Integrated roadside vegetation management

With western Montana roadides occupying thousands of acres, state and county road departments are large-scale vegetation managers. Roadides should be managed cost-effectively to protect the public investment with minimal negative impacts on the environment. Integrated roadside vegetation management (IRVM) accomplishes this by establishing and maintaining long-term, weed-free, self-maintaining roadside plant communities. These plant communities can maintain, restore, and enhance roadides' functions while reducing nuisance and noxious weed encroachment by reducing weed habitat. Management tactics are site-specific and herbicides are used only when necessary. Again, roadside monitoring and evaluation are critical for proper implementation of a successful IRVM plan.

An IRVM plan directs the development and maintenance of healthy, functionally diverse and self-maintaining roadside plant communities. Such communities allow for reduced herbicide use because few resources are available to potential invaders. To encourage growth and vigor in roadside vegetation and further maximize resource competition with weeds, avoid chemical mowing and mechanically mow roadides only when necessary.

Chemical mowing

Chemical mowing is the application of non-selective herbicides in broadcast fashion to the roadides. It works to sup-

The IRVM Process

This is the National Roadside Vegetation Management Association definition of IRVM:

IRVM is a decision-making and quality management process for maintaining roadside vegetation that integrates the following:

- Needs of local communities and highway users
- Knowledge of plant ecology and natural processes
- Design, construction, and performance considerations
- Government statutes and regulations
- Technology with cultural, biological, mechanical, and chemical pest control methods to successfully manage roadides for safety plus environmental and visual qualities

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press growth of roadside vegetation. But because this practice can permanently damage desired vegetation, it is not recommended. Once declared far less disruptive to the roadsides and more economical than the mowers it replaced, in fact chemical mowing results in the visually unremarked spread of some noxious and nuisance weeds (Callcott and Lore 2000). And the permanent damage inflicted on desired vegetation leads to high-maintenance, unhealthy roadides that are prone to noxious and nuisance weed invasions (and that thus need repeated herbicide applications) and erosion.

Mechanical mowing

Mechanical mowing is an important part of roadside maintenance. Proper mowing of certain roadsides furthers safety by maintaining adequate sight distances for motorists and clear zones for use by errant vehicles. However, in many cases mowing is done indiscriminately or too often. This wastes public resources and can negatively affect desired vegetation, resulting in high-maintenance roadides. Encourage the growth and vigor of desired roadside vegetation by mechanically mowing roadsides only when necessary (Goodwin et al. 2000).

For reasons of safety, to maintain adequate sight distances and clear zones, it may be necessary to mechanically mow conditions along state or county roads, especially those that have underdeveloped shoulders. During the active growing season, mow to a height of eight inches. This will promote desired vegetation vigor and continued resource control. When mowing during the dormant period, which for most cool-season grasses comes after mid-July, mowing to two inches is acceptable; grasses are tolerant of short mowing during dormancy.

It is not necessary to mechanically mow roadides when the road—an interstate highway, say—has wide, developed shoulders or for aesthetic purposes.

Mowing and weeds

Besides affecting the competitive vigor of desired vegetation, improper timing of mechanical mowing can also facilitate the spread of noxious weeds. This can occur when roadside maintenance crews mow roadside weeds, usually with flail mowers, after the weed seeds have matured. By the same token, mow maintenance crews, more out of habit than need, mow healthy roadside communities before weed management. This inhibits desired plant seed dispersal for next year’s stand and the flail mowers expose the soil for the weed seed, providing a competitive advantage for the weeds and culminating even more weeds that will need to be sprayed in the future. Activities that give weeds an opportunity to spread must be avoided and prosecuted (Callcott and Lore 2000).

However, by lowering desired plant growth and decreasing the competitive vigor of weeds, properly timed mechanical mow-
ing can be an effective weed management tool. Proper timing of mowing is based primarily on the growth stage of the weeds and secondarily on the growth stage of the desired plants (Shidey et al. 2001).

The most effective time to mow noxious weeds is when the desired plants are dormant and the weeds have reached the flowering stage, well before seed production. Mowing at this time can encourage translocated growth and seed production of desired plants and weaken the weeds while preventing them from producing seed. Long-term repeated mowing of weeds after they have invested a large amount of energy in bolting (when the stem extends from the center of the rosette upwards two to four feet) and producing reproductive structures can eventually deplete root reserves and weaken the infestation. If regrowth holds again and produces flower, an additional mowing will be necessary (Shidey et al. 2001).

When the dominant vegetation is a noxious weed, mow two inches high when the weed is between the early bud and early flowering stage. However, in some cases, noxious weeds will reach the appropriate stage for mowing before the grasses have reached dormancy. If so, mow the weeds at a height above the desired plants. Mowing above the height of actively growing grasses allows continued vige, and defoliating the weeds reduces seed production and vigour, increasing resources available for neighboring grasses (Shidey et al. 2001).

Carefully timed roadside mowing may reduce the seed bank of noxious weeds (Tyler et al. 1990). In a Montana State University study, mowing as the only management tool decreased spotted knapweed density by 85 percent (Ristello et al. 2001). A further reduction in density could be anticipated if mowing were integrated with a herbicide treatment applied to the rapidly developing regrowth one week after mowing.

Consider mowing and applying a herbicide in a single event with a wet-blade mower. This mower’s blade cuts the plants while applying a herbicide. Cuts the herbicide to the roots of the cut plants, advantage of wet-blade mowing has to reduced herbicide rates and runoff and drift. Excellent wet-blade mowing results have been documented for many noxious weeds, including Canada thistle (Cirsium arvense), Russian thistle (Salsola kali), silverleaf goosefoot (Chenopodium argyroclineum), Russian knapweed (Centaurea dealbata) and gustard (Zamaris spp.).

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Appendix C
Understanding succession to direct successful revegetation

Revegetation can be most successful when it works with successional processes to direct communities toward a desired plant community. These components can influence the direction of succession and can be modified to direct predictable successional transitions. These are:

1. Site availability (disturbance) This plays a central role in initiating and altering successional pathways. Site availability can be a desired disturbance such as seeded preparation to produce seed and/or herbicide applications for weed removal to open niches for occupation by desired species. Although site availability is important for the persistence of many native species, it can also facilitate non-native weed invasion (Kotanen 1997).

2. Species availability (colonization) This is the intentional alteration of seed availability by influencing seed bank and propagate pools of desired plants and weeds and the regulation of safe sites for desired plant germination and establishment. Seed seed banks can be depleted through attrition if seed production is prevented or significantly reduced each growing season. For example, Oaten et al. (1997) found that the number of spotted knapweed seeds in the soil was reduced after three years of invasive sheep grazing directed at buds and flower heads, resulting in decreased weed density.

3. Species performance This is the manipulation of the relative growth and reproduction of plants in an attempt to shift the plant community to the desired direction. Domestic sheep can shift a plant community toward desired grasses by selective grazing forbs. By contrast, cattle can shift a plant community toward forbs (e.g., weeds) by selectively grazing grasses. Herbicide applications can alter resource availability and increase desired species performance through competitive weed removal. In other words, soil resources become available for neighboring sown plans through careful herbicide treatment.

Pioneer species (e.g., annual forbs or early-sea species) are usually the first plant types to begin to grow on a disturbed site. These pioneer species are eventually replaced by late-sea species such as grasses that are in turn replaced over time by shrubs and trees. This is plant succession. Non-native weeds act as pioneer species but can then interfere with or arrest succession before it reaches the mid- or late-sea stage most landowners hope to
attain (Munshower 1996). In response, developing a plant community that is more mature than the classic pioneer stage can help ensure that noxious weeds do not become established at the disturbed site. This requires careful weed management.

The final manipulation to a site to make it capable of supporting later-seeded species is topsoiling—if this layer is absent. Since topsoil is generally “mature” enough to support mid-seed stage plants, providing or replacing subsoiled topsoil upon the subsoil strata can move the successional process from the primary level to the secondary. Seedling later-seeded species can further accelerate plant succession.

However, in some cases, the topsoil may lack the maturity needed to support late successional or climax communities. Such plant communities require mature soils with intact and complex nutrient cycles, essential mycorrhizal associations and proper surface litter distribution—and soil microtopographies that can be easily damaged by and following disturbance (Munshower 1994). The introduction of early successional species can direct changes in soil properties that facilitate later successional species. Care in selecting species that complement site soil maturity is recommended.

Although the soil may be mature enough to support some mid- to late-seed species, seeding early-seed species can provide environmental protection—and immediate soil mobility is necessary for the germination and establishment of later-seed species. Pioneer species grow very rapidly and need no protection from wind, sun or high temperatures. By contrast, pioneer species, forbs and shrubs are slow-growing and do need protection—especially during the first growing season (Munshower 1994).
References

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of textured resource characteristics on growth and