

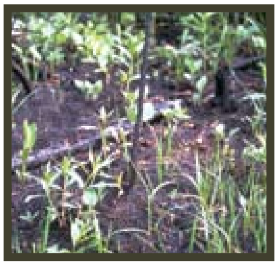
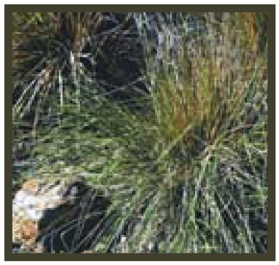

Revegetation Guidelines for Western Montana: Considering Invasive Weeds

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—k.g., g.m., and r.s.

TABLE OF CONTENTS

LIST OF TABLES

PREFACE

Major portions of western Montana's landscape become degraded and disturbed every day. Disturbances can be natural, such as floods and fires, or strictly human-induced, such as roads and construction sites, utility line trenches, or improper grazing. These disturbed areas may recover naturally, but in some cases it may be many years before desired plants become established or recover. Conversely, some areas may never naturally recover because invasive weeds may establish first and prevent native plants from establishing, growing, and reseeding. Furthermore, invasive weeds can potentially spread into adjacent, healthy landscapes where they threaten local biodiversity, alter nutrient and water cycling, diminish wildlife and livestock forage, and increase soil erosion and stream sedimentation.

Natural revegetation can be slow. Artificial revegetation of degraded or disturbed areas can speed or direct recovery and prevent soil erosion. Revegetation can also mitigate weed invasion or reestablishment. Revegetation is also useful where rangeland improvement is desired. Revegetation should only occur when necessary, as determined by the abundance of desired plants and seeds at the site.

This publication provides an in-depth, step-by-step guide to the processes and procedures of establishing desired plant species in the portion of Montana west of the Continental Divide. Detailed information for every situation is beyond the scope of this publication. Site specific or expert advice should be obtained for species selection, establishment methods, and maintenance.

The authors' objective is to help improve the chances of revegetation success by providing practical and effective revegetation concepts and methods for establishing a desired plant community or returning sites to conditions as similar as practicable to the pre-degraded or pre-disturbed state. Depending on your situation, this process may entail many steps: salvaging resources, protecting key plant-community components, preparing the site appropriately, reducing weed interference, designing a proper seed mix, and seeding using the most effective method. Establishment should be monitored to quickly identify problems that could prevent or interfere with successful revegetation. Following establishment, proper vegetation management favoring the seeded species will be necessary. This includes long-term maintenance of the desired plant community and deterring establishment of invasive weeds.

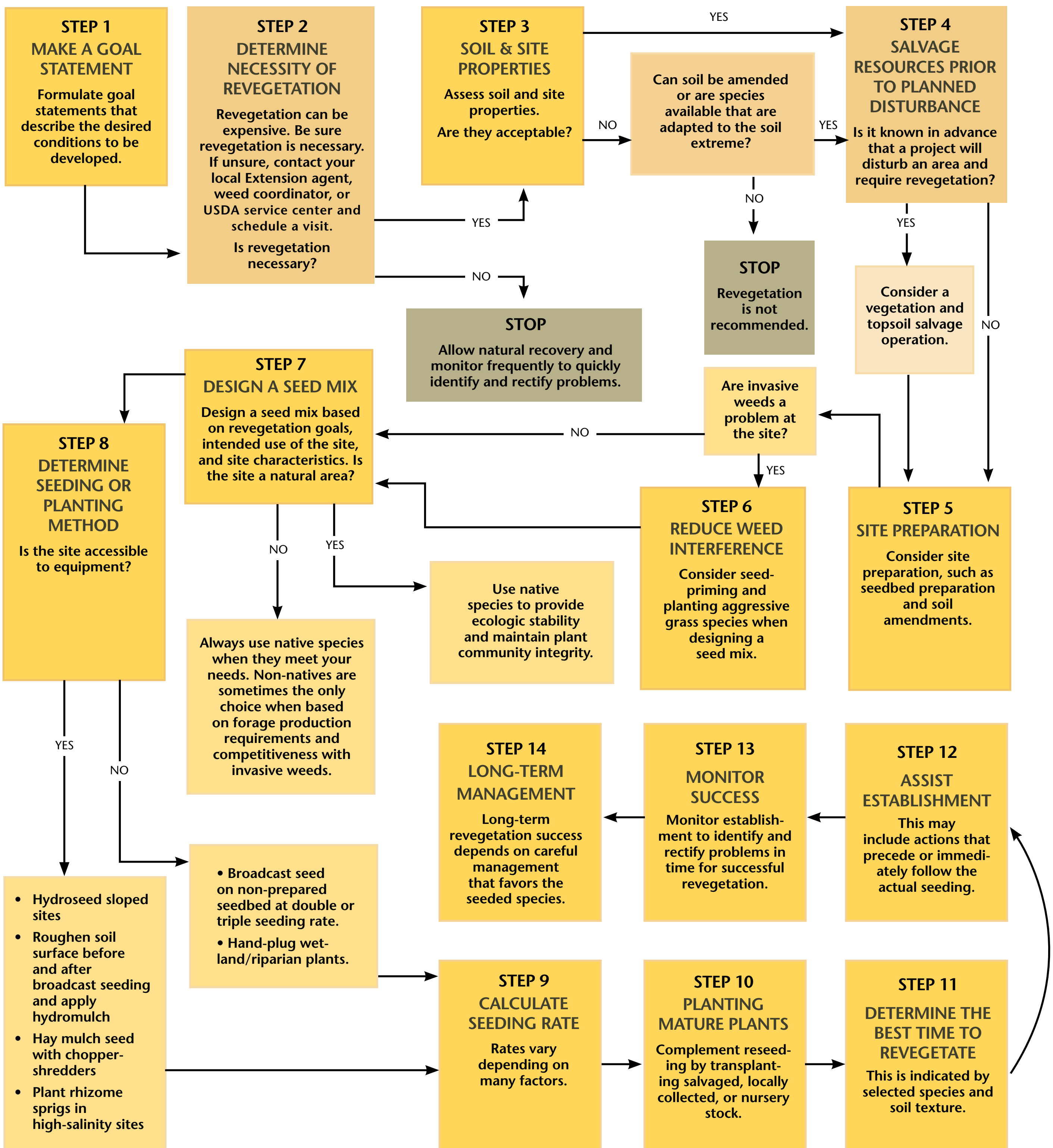
Kim Goodwin

Gerald Marks

Roger Sheley

Missoula
May 2006

CHECKLIST OF ACTIONS



STEP 1

MAKE A GOAL STATEMENT

Invasive weeds are considered one of the most serious problems facing land managers in the western region of the United States. These non-native plants have the ability to invade and irreversibly damage the structure and function of biological communities and ecosystems by displacing native plants and animals.

Land managers often focus on controlling weeds, with limited regard to the existing or resulting plant community. On grasslands, forests, and roadsides, the effectiveness of various weed management strategies depends on land use and management. Invasive weeds can permanently alter the structure, organization, and function of ecologic systems and must be considered when establishing management and revegetation goals. This implies weed control alone is an inadequate goal, especially for large-scale infestations. A generalized goal for weed management is to develop and maintain a healthy plant community while meeting other land use objectives such as forage production, wildlife habitat development, or recreation land maintenance. Revegetation efforts are often a key component of weed management.

Defining project goals and objectives is the most important step in planning a weed management or revegetation project. By setting goals and objectives, you will be able to determine if your management is working or if you should adapt your management practices. Goal statements should describe the desired conditions to be developed. You should ask, "What do I want to accomplish?"

Revegetation goal statements may include any of the following:

- ❑ Improve rangeland forage production or rehabilitate degraded or disturbed sites.
- ❑ Quickly reestablish vegetation to minimize erosion.
- ❑ Establish species that can minimize weed invasion or reestablishment.
- ❑ Restore a healthy plant community.

Jim Brown, the North Hills–Missoula, 1974

The goal statement of the Missoula County Weed Management Plan is to "minimize the impact of noxious weeds through the use of sound ecological practices." Maintaining desired plant communities is the most effective and ecologically sustainable weed management strategy.

Setting objectives is useful because they provide a measurable link between goal statements and revegetation actions. To increase the likelihood of successful revegetation, objectives should consider site characteristics, land use, economic constraints, realistic timeframes, and performance measures.

The following is an example of a revegetation objective:

- ❑ Reduce invasive weed canopy cover by 25 percent and increase native grass canopy cover by 10 percent one year after herbicide treatments and revegetation.

STEP 2

DETERMINE THE NECESSITY OF REVEGETATION

Revegetation should only be performed when necessary. Determine if adequate desired vegetation is present at the site to meet your revegetation goals and objectives. Revegetation may be necessary when desired plants are inadequate at the site.

RANGELAND 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 while maintaining the forage resource is essential. Often this includes seeded pastures that supply nutritious forage at various times during the year when other sources are inadequate or unavailable. Revegetating to meet this need and improve rangelands is often necessary.

EROSION CONTROL

Disturbances that create bare slopes may require revegetation, possibly in combination with certified weed-free mulch, netting, or erosion control blankets to mitigate erosion while assisting establishment of the seeded species. For example, some wildfire-affected areas require revegetation to speed recovery and prevent erosion. These areas include sites with severe burns, stream corridors, and slopes greater than 15 percent (see "Revegetation after wildfire," overleaf).

Burned sites with disturbed and exposed soil usually require revegetation to speed natural recovery.

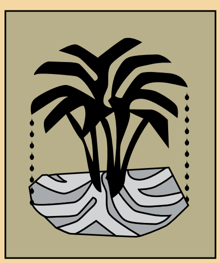
DESIRED PLANT INTRODUCTION

Weed-infested sites with inadequate desired plant canopy cover (see sidebar), usually less than 30 percent when compared to percent of non-desired plant cover, may require revegetation with competitive plants to meet land management goals. On these sites, weed control is often short-lived because desired species are not available to occupy small sites.

Introducing competitive grasses, and eventually forbs (herbaceous flowering plants), will be essential for successful long-term management of weed infestations and the restoration of desired plant communities. Weed density should be significantly reduced to minimize competition with seeded species. This will require effective management for the first couple of years or longer to weaken an infestation and reduce weed competition for light, water, and nutrient resources to allow desired species to establish.

With effective, long-term weed management, weed-infested sites with more than 30 percent desired vegetation canopy cover, when compared to percent of non-desired plant cover, do not usually require revegetation. In such cases, adequate desired plants are present to direct natural revegetation with appropriate weed control. Desired grasses and forbs steadily occupy open spaces made available by weed removal.

Canopy cover is the area of ground covered by the vertical projection of the outermost perimeter of the natural spread of plant foliage. Small openings within the canopy are included.



To determine the desired plant canopy cover of a site:

1. Make a hoop made from coated cable up to ½ inch thick (available at most farm and ranch supply outlets). Purchase 93 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.) Overlapping canopies should be counted.
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 or the number of times the hoop was tossed) to determine the average desired plant canopy cover.

STEP 2

DETERMINE THE NECESSITY OF REVEGETATION

REVEGETATION AFTER WILDFIRE
(adapted from Wiersum et al. 2000)

Revegetation is recommended in some burned areas after wildfire. Contact your local USDA Service Center to schedule a site visit and an assessment. Revegetating only when necessary will avoid suppressing the recovering native plant community and conserve limited resources.

Revegetation following wildfire depends on many factors, including:

- ❑ **Burn severity**–A high-severity fire can permanently damage desired plants and propagules, greatly limiting natural recovery. Runoff increases on slopes due to hydrophobic (water-repellent) soils and a lack of vegetation to absorb and use rainfall. Lack of competitive plants favors weed invasion. Revegetation is usually recommended on high severity burn sites, especially when slopes are present or weeds are a serious threat.
- ❑ **Slope**–Moderate severity burns on slopes greater than 15 percent usually require quick soil protection with annual ryegrass *(Lolium multiflorum)* or small grains. Stabilizing surface movement with weed-free hay mulch secured with netting or an organic tackifier is recommended. Soils benefit from cross-slope log erosion barriers or contour scarification when hydrophobic soils occur. Slash filter windrows at toe-slopes also improve soil stabilization.
- ❑ **Proximity to drainages**–Revegetate channels to mitigate serious erosion during increased flows and to filter sedimentation from runoff. For quick temporary cover and protection, annual ryegrass at 10 pounds per acre or small, sterile grains at 20 pounds per acre are frequently seeded within 50 feet of drainage channels, regardless of burn severity. Installing temporary check structures in ephemeral drainages is also beneficial.
- ❑ **Pre-burn invasive weed cover**–Sites with inadequate desired plant cover should be considered for revegetation regardless of burn severity. Revegetation will usually be necessary given moderate to high weed cover coupled with lack of competitive plants and such fire-produced disturbances as increased nutrients and high light conditions.
- ❑ **Exposed soil**–New roads, firebreaks, embankments, and cut-and-fill slopes should be revegetated. During wildfire rehabilitation, replace soil that was pushed aside during firebreak development. By replacing this topsoil, revegetation may not be necessary if the soil contains an adequate amount of desired plant propagules. Replace this topsoil as soon as possible and with a minimum number of machine passes.

Fast-growing, non-persisting annuals such as annual ryegrass or wheat (*Triticum aestivum*) varieties are often seeded as companion crops with perennial grasses in wildfire-affected areas. The companion crop establishes quickly to protect soil and young, slower-establishing perennial grasses. Planting conifer seedlings is beneficial in speeding natural recovery.

Karen Wattenmaker

Revegetation is usually necessary following high-intensity, high-severity burns.

STEP 3

SOIL & SITE PROPERTIES

It is important to determine if revegetation is likely to succeed or fail prior to implementation. Several soil properties provide a good indication of the likelihood for revegetation success. In some cases, problematic soil properties can be amended. For instance, soils with low organic matter can be amended with the addition of compost. Highly saline or alkaline soils can be amended with sulfur, peat, lime, or fertilizer. A better alternative to amending saline or alkaline soils, however, is to seed with species adapted to these soil extremes.

Inland saltgrass (*Distichlis spicata*) is a native grass that grows well in unusually saline areas. Altai wildrye (*Leymus angustus*) is a non-native bunchgrass that is extremely saline–alkaline resistant. Slender wheatgrass (*Elymus trachycaulus*) is a tall native bunchgrass with rapid establishment and saline tolerance. This plant is adapted to a wide range of sites. Tall wheatgrass (*Thinopyrum ponticum*) is very tall non-native bunchgrass with easy establishment and saline tolerance. Other plants that perform well in saline–alkaline sites are footnoted in Tables 2, 3, and 4.

The decision index on the following page will help assess soil condition. This information is available in most USDA Natural Resources Conservation Service (NRCS) county soil surveys. Soil testing provides more accurate and site specific information. Contact your county Extension agent or local USDA Service Center to assess soil condition or if your soil properties are outside the acceptable range.

Robert Soreng @ USDA–NRCS PLANTS Database

Slender wheatgrass is a native bunchgrass adapted to saline sites.

STEP 3

SOIL & SITE PROPERTIES

SITE CHARACTERISTICS

Site characteristics such as soil attributes, annual precipitation, soil moisture, temperature, and elevation need to be considered early during a revegetation project. This will help refine the goals and objectives related to your desired plant community, appropriate species selection, and seeding method.

SOIL ATTRIBUTES

Soil texture, which is determined by the size and distribution of the soil particles (sand, silt and clay), is an important characteristic that can direct species selection. Most seeded species prefer medium- to fine-textured soils. However, Indian ricegrass (*Achnatherum hymenoides*), a very drought-tolerant native bunchgrass, is well adapted to sandy soils. Western wheatgrass (*Pascopyrum smithii*), a native rhizomatous grass, does well on heavy clay soils. Loam soil texture is considered ideal and consists of 45 percent sand, 35 percent silt and 20 percent clay. See "manual texturing" overleaf to learn how to measure soil texture.

Determining the chemical properties of soil can also be helpful in directing or confirming species selection and identifying needed soil amendments. Soil chemistry also indicates the suitability of the soil for plant survival and growth.

If you are planning a challenging revegetation project, contact local experts and consider testing the soil for:

pH— This is a measure of the activity of hydrogen ions in a solution, or its acidity or alkalinity. The optimal range is 6.5 to 7.5. Alkaline soils are usually derived from chalk or limestone. Use species adapted to highly alkaline soils instead of attempting to amend the soil. Grasses, grasslike species, and forbs adapted to alkaline conditions are footnoted in Tables 2, 3, and 4.

Electrical conductivity— This is a measure of soil salinity. The optimal range is 0 to 2 mmhos/cm soluble salts. Salinity is important because it influences the types of plants that will grow in an area. Grasses, grasslike species, and forbs adapted to saline conditions are footnoted in Tables 2, 3, and 4.

Sodium adsorption ratio (SAR)— This is the proportion of sodium ions to the concentration of calcium plus magnesium ions in the saturation paste; optimum is <6. When SAR rises above 12, serious physical soil problems arise and plants have difficulty absorbing water.

Organic matter— This is a measure of the percent organic material in the soil; optimum is >3 percent. Organic matter increases soil porosity, water infiltration, water-holding capacity, 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 seeded species.

Use this decision index to determine whether revegetation is likely to succeed without the addition of amendments.

Soil parameter	Ideal condition	Acceptable range	Insert the properties of your soil	Are your soil properties within the acceptable range?
Soil texture (sand, silt, clay)	Loam	Clay loam to sandy loam		
pH	6.5 – 7.5	5.5 – 8.5		
Electrical conductivity (salinity) (mmhos/cm soluble salts)	0 – 2	< 8		
Sodium adsorption ratio	< 6	< 12		
Organic matter (percent in soil)	> 3	< 2		

STEP 3

SOIL & SITE PROPERTIES

ANNUAL PRECIPITATION, SOIL MOISTURE, TEMPERATURE, AND ELEVATION

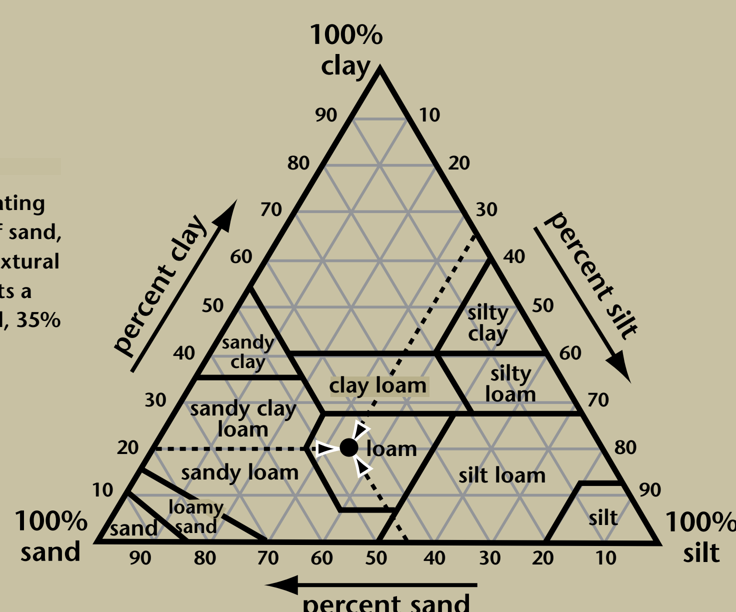
Revegetation projects should be adapted to the annual precipitation and soil moisture level of the site. Temperature zone and elevation of the site should also be considered. Obtain the USDA Plant Hardiness Zone Map from your local USDA Service Center to consider species survival, especially for shrubs, based on average winter minimum temperatures. See Table 5 for recommended grass species for western Montana by zone.

Plant species selection and seeding methods should be suited to site conditions. For example, many species perform well on high-soil-moisture sites like stream bottoms or wet meadows subirrigated for at least part of each growing season. Subirrigated sites have a permanent water table within about 3.5 feet of the surface.

Beardless wildrye (*Leymus triticoides*) is a native grass adapted to a wide variety of soils that are subirrigated, wet, or occur in annual precipitation zones greater than 18 inches. Other suitable natives include western wheatgrass and tufted hairgrass (*Deschampsia caespitosa*). Although not native, orchardgrass (*Dactylis glomerata*), meadow brome (*Bromus biebersteinii*), and tall fescue (*Lolium arundinaceum*) are often used for irrigated pastures in Montana. Other non-native grasses that perform well in irrigated pastures are footnoted in Table 3. Numerous native grasses, and forbs are available for wetland/riparian revegetation projects; see footnotes in Tables 2 and 4.

MANUAL TEXTURING

You can approximate the amount of sand, silt, and clay in soil by using a simple method called "manual texturing." The feel of the moist soil sample, when rubbed between the thumb and forefinger, determines the texture. If the sample is predominantly sand, it will feel coarse and gritty. If it is predominantly silt, it will feel smooth or slippery to the touch. And if predominantly clay, it will feel sticky and fine.



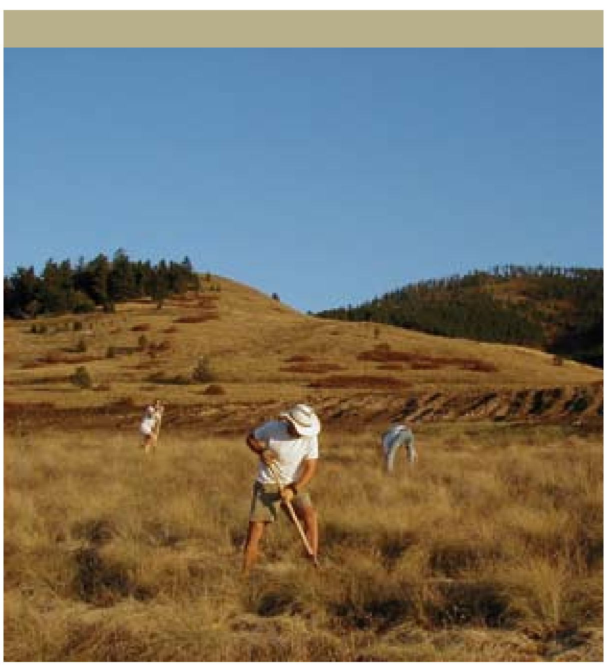
Soil textural triangle illustrating the range in composition of sand, silt, and clay for each soil textural class. The dotted line depicts a loam soil that has 45% sand, 35% silt, and 20% clay content.

STEP 4

SALVAGE VEGETATION AND TOPSOIL PRIOR TO PLANNED DISTURBANCES

Consider salvaging a portion of the vegetation from the site before a planned disturbance to avoid permanently losing this resource. This vegetation is already adapted to the site and when replaced, it may supplement the revegetation process (see Step 10, Planting Mature Plants). For instance, blocks of the existing native sod can be removed, stored, and replaced after the construction work has been completed. As an alternative to salvaging whole plants, some seed companies offer on-site seed collection and custom grow-outs. For large or long-duration projects, the collected material can be cultivated for a steady seed supply in subsequent years. This ensures the seeds are genetically adapted to local conditions.

Also consider salvaging weed-free topsoil from the site before a planned disturbance. Topsoil contains living plant propagules such as seeds, plant fragments, and whole plants. These are valuable revegetation resources adapted to the site. Topsoil also contains earthworms, insects, and beneficial microorganisms, such as bacteria and fungi. Biological activity in this zone cycles soil nutrients, increases nutrient availability, aerates the soil, maintains soil structure, and increases soil water-holding capacity. Reapplication of healthy topsoil enhances revegetation and promotes establishment of vegetative cover. Topsoil that is damaged or unfit, for instance containing invasive weeds, should not be salvaged. It should instead be removed and replaced with weed-free topsoil.


Lisa Lewis

Salvaging native plants prior to disturbance can supplement revegetation and preserve local native gene pools and ecotypes.

Avoid damaging topsoil by keeping the soil alive, protected, and weed-free until it can be returned to the site. Salvage topsoil operations usually occur during the fall while the soil is moist (not wet). This prevents depressing potential recruitment of seeds that are present in the soil. Store as briefly as possible and in piles less than two feet high, exposing as much soil to air as possible to avoid damaging microorganism numbers with anaerobic conditions. A study in Yellowstone National Park demonstrated topsoil stripped and replaced within 90 days retains viable populations of mycorrhizae fungi, but topsoil stored over a winter lost most of its mycorrhizal activity. If you must store topsoil longer than a few weeks, sow it with a protective cover crop such as Regreen, a sterile hybrid cross between common wheat and tall wheatgrass (*Triticum aestivum* x *Thinopyrum ponticum*), or triticale, a sterile hybrid cross between common wheat and cereal rye (*T. aestivum* x *Secale cereale*). Monitor the stored topsoil often and remove invasive weeds.

When replacing topsoil to a site, do so with a minimum number of machine passes to prevent soil compaction. Schedule revegetation within a few days of topsoil replacement. Topsoil should be spread evenly over the surface, at least six inches deep. A study conducted at a northwest Colorado mine site demonstrated topsoil spread to this thickness was sufficient for the establishment and continued productivity of herbaceous, or non-woody, vegetation. This study found deeper topsoil depths (12, 18, and 24 inches) were associated with plant communities dominated by grasses. Shallow topsoil depths supported more diverse plant communities with significantly greater forb production and shrub density.

STEP 5

SITE PREPARATION

Appropriate site preparation is important to ensure revegetation success. A variety of techniques and practices exist and the appropriateness of these will vary with site conditions, seeding method, species selection, available resources, and revegetation goals.

SITES WITH COMPACTED SOIL

Soil consists of organic material, air spaces, and particles of sand, silt, and clay. A loss of soil structure from compaction, excessive tillage, or tillage when soil is too wet affects soil processes. Compaction limits air exchange to roots and the ability of water to percolate through the soil. Compaction also limits the number of seed safe sites, or areas suitable for germination and growth.

To improve soil structure and prepare a favorable seedbed for germination, compacted sites should be scarified or plowed. Scarification is a form of ripping that breaks up topsoil aggregates by raking the soil surface with ripper shanks pulled behind a tractor, grader, or bulldozer. In sites where the topsoil has been removed, ripping subsoils to a depth of 6 to 12 inches before adding topsoil is recommended.

SEEDBED PREPARATION

Compacted soil always requires seedbed preparation. The degree of seedbed preparation in other cases depends partly on the seeding method (See Step 8, "Determine a Seeding Method"), which is influenced by site accessibility, terrain, and seedbed characteristics. Seedbed preparation is usually not necessary when drill seeding. Seedbed preparation is recommended when broadcast seeding or hay-mulch seeding.

The ideal seedbed contains adequate seed safe sites, while being firm enough to allow good seed-to-soil contact and loose enough for the seed to sprout and penetrate the soil. Seedbed firmness is ideal when, walking across it, footprints remain that are about four inches deep.

A seedbed can be prepared through shallow chiseling, plowing, harrowing, or dragging small chains. Plowing loosens the upper layer of soil and increases the number of seed safe sites. Plowing should be carefully considered, as it may permanently damage existing desired vegetation and cause erosion on slopes or in fine-textured soils. Also carefully consider deep plowing on sites with invasive

Ash produced by a fire provides an excellent seedbed. A fall dormant broadcast seeding into the ash layer will cover and retain seeds until suitable conditions exist for germination the following spring.

weeds. Deep plowing promotes nitrogen release, which favors heavy weed growth. Consider reducing nutrient availability to weeds by sowing a fast-growing cover crop if plowing is necessary.

Harrowing and raking are secondary tillage operations that use spiked or toothed cultivating implements to uniformly roughen the soil surface. Small chains may function similarly. These operations are less destructive than plowing and are recommended when broadcast seeding into plant communities that still contain desired plants. Secondary tillage operations can be used before broadcast seeding to break up crusts and after broadcast seeding to lightly cover seeds with soil. Light packing of the soil following broadcast seeding is also beneficial for adequate seed-to-soil contact. The application of hydromulch following broadcast seeding is beneficial.

A harrow can improve germination of broadcast seed by roughening and loosening the soil surface.

SOIL AMENDMENTS

Amendments are added before or shortly after seeding to provide a better medium for plant growth. Soils with low organic matter can be amended with compost. Highly saline or alkaline soils can be amended with sulfur, peat, lime, or fertilizer, but planting species adapted to these soil extremes is recommended. Adding nitrogen can assist establishment in some cases. Additions of soil microorganisms may also assist establishment.

Nitrogen fertilizers should only be used when soil tests show a gross deficiency. The addition of non-essential nitrogen can reduce important mycorrhizal activity and encourage heavy weed growth. In a recent Montana State University study, the main responses to nitrogen fertilization in a dryland situation were increased invasive annual grass or annual weed production and decreased plant diversity. Rarely is nitrogen needed for native species, especially late-seral grasses such as bluebunch wheatgrass (*Pseudoroegneria spicata* ssp. *spicata*). Late-seral grasses represent the climax of plant community succession (see "Understanding Succession to Direct Successful Revegetation" overleaf). These grasses have minimal nitrogen requirements, having evolved in low-nutrient environments. Reducing the amount of available nitrogen in the soil may increase late-seral grass establishment by reducing weed competition. For this reason and when seeding late-seral native grasses in moderate- or high-nitrogen sites, consider a low rate seeding (< 20 lbs PLS/acre) with a sterile companion crop, such as Regreen, to sequester nitrogen. Companion crops also benefit seeded species by protecting seeds and soil from wind and water erosion, conserving soil moisture, moderating soil temperatures, and protecting seedlings.

Fertilizers may be necessary in mesic or wet sites when rapid growth and maximum production is desired with agronomic species, such as tall fescue. The high nitrogen requirements of this non-native grass make it well suited for use in mixtures with nitrogen-fixing legumes such as alfalfa.

Soil microorganisms process mulch and dead plant material into nutrients available for plant uptake. 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 and improve nutrient uptake, drought tolerance, and pathogen resistance of host plants. 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. Mycorrhizal fungi can be naturally established by collecting the top litter layer from a local weed–free landscape and working it into the topsoil of the revegetation site or by planting shrubs that can capture wind-blown mycorrhizal spores. Mycorrhizal inoculation of locally collected or salvaged nitrogen-fixing plants or nursery stock may benefit a project. If determined beneficial, place inoculum below the seedling at transplant stage or dip bareroot stock in adhesive-treated inoculum.

STEP 5

SITE PREPARATION

UNDERSTANDING SUCCESSION TO DIRECT SUCCESSFUL REVEGETATION

Pioneer, or early-seral species, like annual forbs, are usually the first plant types to begin to grow on a disturbed site. Early-seral species are eventually replaced by later-seral species, such as grasses that are in turn replaced over time by shrubs. This is plant succession. Invasive weeds act as pioneer species but can then interfere with or arrest succession before it reaches the mid- or late-seral stage most landowners hope to attain. In response, developing a plant community that is more mature than the classic pioneer stage can help ensure invasive weeds do not become established in disturbed sites.

The first manipulation to a site to make it capable of supporting later-seral species is topsoiling—if this layer is absent. Since topsoil is generally "mature" enough to support mid-seral stage plants, adding salvaged topsoil upon the subsoil strata can move the successional process from the primary to the secondary level. Seeding later-successional, or late-seral, species can also accelerate plant succession.

In some cases, however, the topsoil may lack the maturity needed to support late successional or climax communities. These plant communities require mature soils with intact nutrient cycles, essential mycorrhizal associations, and proper surface litter distribution—soil micro-topographies that can be easily damaged by disturbance. The introduction of desired, early successional species can direct changes in soil properties that promote establishment of 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-seral species, seeding early-seral species can provide environmental protection and immediate soil stability necessary for the germination of later-seral species. Pioneer species grow very rapidly and need no protection from wind, sun, or high temperatures. By contrast, perennial grasses are slow-growing and need protection—especially during the first growing season.

Revegetation can be most successful when it works with successional processes to direct plant communities toward a desired state. Three 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 designed disturbance such as seedbed preparation to produce seed safe sites or herbicide applications for weed removal to open small areas for occupation by desired species. Although site availability is important for the persistence of many native species, it can also promote weed invasion. So, be sure to frequently monitor for new weeds.

Most land managers strive to attain late successional plant communities, such as this late-seral bunchgrass/sagebrush plant community.

2. **Species availability (colonization)**—This is the intentional alteration of seed availability by influencing seed banks of desired plants and weeds. Weed seed banks can be depleted through attrition if seed production is prevented or significantly reduced each growing season. For example, a recent Montana State University study found the number of spotted knapweed seeds in the soil was reduced after three years of intensive sheep grazing of buds and flower heads, resulting in decreased weed density. Desired plant seed banks can be increased through revegetation.

3. **Species performance (competition)**—This is the manipulation of the relative growth and reproduction of plants in an attempt to shift the plant community in the desired direction. Domestic sheep can shift a plant community toward desired grasses by selectively grazing weedy forbs. By contrast, cattle can shift a plant community toward forbs and shrubs by selectively grazing grasses. Herbicide applications can alter resource availability and increase desired grass performance through competitive weed removal. This makes soil resources more available to desired plants nearby.

STEP 6

REDUCE WEED INTERFERENCE

Establishment of seeded species in weed-infested sites depends on significant reduction of invasive weed competition, or interference. When revegetating weed-infested sites, strategies to reduce weed competition will be necessary. These strategies include absorbing nutrients with cover crops, mowing, herbicides, biological control insects, and/or grazing.

Reducing the availability of nutrients to weeds can reduce weed interference with seeded species, especially late-seral native grasses. Sites high in nitrogen favor quick-growing invasive weeds and sites with low nitrogen favor slow-growing, late-seral grasses. A Montana State University study demonstrated sowing cereal rye, an early-seral cover crop, dramatically lowered nitrogen and shifted the competitive advantage from spotted knapweed (*Centaurea maculosa*) to bluebunch wheatgrass. Fast-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-seral cover crop the year before revegetating with mid–or late-seral grasses.

Managing infestations with mowing, herbicides, biocontrol, or grazing for the first couple of years, or longer, prior to seeding may weaken an infestation. This will reduce weed interference and favor seeded species. For instance, mowing spotted knapweed can be effective in reducing seed production and weakening an infestation. Research at Montana State University demonstrated mowing as a single management tool decreased spotted knapweed density by 85 percent after two years when mowing was done during the early bud stage.

Integrating mowing with other management tools may further reduce weed density. Combining mowing with an appropriate herbicide applied one month after the last mowing cycle to the rapidly developing regrowth is effective. Consider mowing and applying herbicide in a single efficient entry with a wet-blade mower (see Appendix B).

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 weeds and invasive annual grasses, such as cheatgrass (*Bromus tectorum*). When cheatgrass seedlings are present in the mid–to late fall, this strategy can substantially reduce competition for early-season moisture the following spring. When invasive forbs are dominant, a single-entry revegetation operation may be considered if the site is accessible to equipment (see "Single-Entry Revegetation" overleaf).

Young grass seedlings can be sensitive to many herbicides. Although herbicide recommendations are beyond the scope of this document, some generalizations can be set forth. The application of bromoxynil at the three- or four-leaf grass seedling stage enables early suppression of young broadleaf weeds while limiting injury to seeded grasses. The herbicide 2,4-D may be used once the grass seedlings have reached the four- to six-leaf stage, or later. On the other hand, studies have demonstrated the application of picloram at 1/2 to 1 pint per acre did not injure seeded grasses, even with the two- to three-year soil residual. Grass injury did occur, however, when picloram was applied at 2 quarts per acre. Contact your local weed district or Extension office for herbicide recommendations and rates.

Biological control is the use of live natural enemies to reduce weed populations. Biological control agents, such as insects, stress the weeds and reduce overall plant production, but do not kill the plants. Insect biocontrols are most effective when integrated with other weed control measures. Another type of biological control includes the use of grazing animals. This is a very effective method of weed control when performed at proper timing and intensity. Many invasive weeds provide good forage for sheep or goats, which have a dietary preference for forbs. Although grazing does not kill the weeds, at sufficient and proper intensity it can effectively deplete seed production and root reserves to weaken an infestation. The competitive ability of the weeds are reduced and control treatments become more effective. An intensive grazing system that includes a minimum of two grazing periods in a season, each followed by a rest period, is more effective than season-long grazing. Contact your county Extension agent or the Montana State University Sheep Institute to design a grazing strategy. Contact your local weed district for biocontrol insects.

STEP 6

REDUCE WEED INTERFERENCE

"SINGLE-ENTRY" REVEGETATION

Weed control is often short-lived in areas dominated by invasive weeds because desired species are not available to occupy small areas opened by removed weeds. Weed-infested sites lacking an adequate amount of desired species require revegetation for successful long-term weed management. However, revegetation of weed-infested sites is often expensive because of the number of attempts required for success and the number of field entries needed to maximize the potential for seedling establishment.

Revegetation of weed-infested sites has customarily required multiple entries:

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

2. A few weeks later, a non-selective herbicide, such as glyphosate, is applied to manage newly emerging weeds. The combination of tillage and herbicide reduces weed-seed density and weed competition the following spring.

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

4. The following spring, the remaining weed seeds and seeded grasses germinate and emerge. With adequate spring precipitation, both weed and grass seedlings survive. If grass seedlings survive until midsummer, a broadleaf herbicide, such as 2,4-D, is applied to reduce weed interference.

Successful revegetation of weed-infested sites can be expensive when multiple entries are required. By contrast, a "single-entry" approach can direct cost-effective and reliable revegetation. In one late-fall field entry, a residual broadleaf herbicide can be applied at the very time grasses are seeded with a no-till drill.

A recent Montana State University study combined eight herbicide treatments and three grass species at two Montana sites infested with spotted knapweed. The best revegetation success resulted with a fall application of picloram at one half or one pint per acre with 'Luna' pubescent wheatgrass (*Elytrigia intermedia* ssp. *trichophorum*) as the seeded species. This cost-effective and reliable "single-entry" strategy may be considered a major component of many sustainable weed management programs.

STEP 7

DESIGN A SEED MIX

When selecting species, varieties, or cultivars, choose those most appropriate to the revegetation goals and environmental conditions of the site. These include soil attributes, and annual precipitation, temperature, and elevation. These factors may vary across different parts of the revegetation area.

The selection and use of native species is strongly encouraged. This will promote ecologic stability and plant community integrity and reduce the risk of seeding an aggressive or invasive species. Native species seed availability is listed in the *Source Guide for Native Plants of Montana*, published by the Montana Native Plant Society. This guide lists over 55 sources for over 500 native plant species. Ordering information is available at http://umt.edu/mnps/. The USDA PLANTS Database provides plant profiles with synonyms, classifications, distribution maps, images, and additional sources and references for plant species, available at http://plants.usda.gov/. This USDA web site also hosts VegSpec, a web-based decision support system to assist land managers in planning and designing revegetation projects. VegSpec utilizes soil, plant, and climate data to select plant species that are site-specifically adapted, suitable for the selected practice, and appropriate for the goals and objectives of the revegetation project. Contact your local USDA Service Center or Extension agent to assist in the design of a proper seed mix that also addresses species compatibility.

Take care to ensure adequate species diversity in a revegetation seed mix. Experts advise several species of grasses, but not more than five, should be seeded to cover the range of site conditions and increase the chances of revegetation success. When developing a seed mix, consider species compatibility, as seedling vigor varies by species. Some vigorous species develop rapidly, often at the expense of other species in the mix. For instance, non-native tall wheatgrass should be seeded alone, as it will completely dominate a site after four or five years. Species characterized by slow-developing, non-aggressive seedlings, such as non-native Russian wildrye (*Psathyrostachys juncea*) and tall fescue, should also be seeded alone. Birdfoot trefoil (*Lotus corniculatus*), an introduced legume, is intolerant of competition from other plants and performs best alone. Unless the site is to be grazed, avoid mixing tall-growing grasses with such shade-intolerant legumes as birdsfoot trefoil. These grasses can suppress legume performance.

Arrowleaf balsamroot is a large, long-lived, native forb. It is an important forage plant during spring and early summer.

When purchasing seeds, ensure the seed is weed-free. To improve quality and establishment, purchase certified seeds. (Bags of such seed bear blue "certified seed" tags.) Certification guarantees the seeds have the same genetic potential to perform in the field as the breeder seeds of the variety when it was first released for production. For instance, when purchasing certified 'Tegmar' intermediate wheatgrass (*Thinopyrum intermedium*), you are sure to have dwarf intermediate wheatgrass plants to meet your revegetation goals. Avoid purchasing preformulated wildflower seed mixes. A recent University of Washington study found 19 packets of wildflower seed mixes contained anywhere from 3 to 13 invasive plant species. Rather than purchasing preformulated mixes, buy certified wildflower seeds species by species—and make sure they are native to the region.

Table 1. Season of use for selected western Montana forage species (adapted from Holzworth et al. 2000)

NATIVE	SPRING	SUMMER	FALL	WINTER	NON-NATIVE
Sandberg bluegrass Big bluegrass	✓				Sheep fescue
Blue wildrye		✓			
Bluebunch wheatgrass Beardless wheatgrass Streambank wheatgrass Thickspike wheatgrass Canada wildrye Mountain brome Prairie junegrass Sand dropseed Prairie coneflower Prairie clover *(fall grazing possible)* Boreal sweetvetch	✓	✓			Tall wheatgrass Intermediate wheatgrass
Idaho fescue	✓	✓	✓		Newhy hybrid wheatgrass Pubescent wheatgrass Orchardgrass Alfalfa Sainfoin
Basin wildrye Needle and thread	✓			✓	
		✓	✓		Birdfoot trefoil Cicer milkvetch
Western wheatgrass		✓	✓	✓	
Maximilian sunflower *(best if used as winter forage)*	✓	✓	✓	✓	Russian wildrye Meadow brome Small burnet
Slender wheatgrass Indian ricegrass	✓	✓		✓	

Recent interest in native wildland seed collection and the need for well-adapted native species for reclamation has prompted a seed certification class for wildland collections. The "Source Identified Class" verifies the species and origin of wildland seed harvests. Seeds with yellow certified seed tags have been harvested following approved guidelines and procedures. The tags confirm the species and origin of the harvest. Wildland seeds may have long-term resiliency, but large quantities must often be collected to offset low seed viability. Custom-collecting by commercial harvesters is possible, and may be necessary for large projects when site-specific seed is desired or when preferred species are not commercially available.

A list of selected forage species based on desired season of use is provided in Table 1. Recommended native grasses and grass-like species are listed in Table 2. A list of non-native grasses for typical projects is provided in Table 3, and selected forb and shrub species are listed in Table 4. Selection of species should be determined by revegetation goals and objectives and specific conditions of the site.

STEP 7

DESIGN A SEED MIX

REVEGETATION GOALS

IMPROVE RANGELAND FORAGE PRODUCTION OR REHABILITATE DEGRADED OR DISTURBED AREAS

Rangeland improvement—Many native and non-native species are appropriate for rangeland improvement. Mixtures of species with differing palatability are usually not recommended, as some will be overgrazed while others are under utilized. For instance, needle-and-thread (*Hesperostipa comata*) is preferred less than other grasses. And the relatively low palatability of tall wheatgrass makes it necessary to have pastures fenced separately, giving livestock no forage alternative. Seed mixtures should be designed with careful attention to species compatibility to avoid reversion to a few species over time. A series of dryland pastures with one or more planted to spring-grazed species and others planted to summer or fall species may be an option.

Consider pasture management and the ability of the species to supply forage when needed (Table 1), then design the seed mix to accommodate seasonal forage requirements. For instance, good winter protein and energy make sagebrush (*Artemisia* spp.) valuable winter forage. Bitterbrush (*Purshia tridentata*) provides high year-round nutrition, but maximum plant performance is maintained when it is used as winter forage.

Prairie junegrass is a native bunchgrass adapted to sandy soil.

Larry Allain @ USGS

Forage production can be enhanced with a seed mixture of productive cool-season grasses and a deep-rooted legume. Cool-season plants initiate growth in early spring. This seed mix produces more high-quality forage than grass alone. For instance, orchardgrass alone will yield an average of 1 to 2 tons per acre of hay, but can yield a maximum of 2 to 3 tons per acre when grown with clover or alfalfa. To avoid bloat, replace alfalfa with low-bloat legumes such as native vetches or sainfoin (*Onobrychis viciifolia*), cicer milkvetch (*Astragalus cicer*), or birdfoot trefoil.

Following seeding, and if appropriate to the site, consider planting shrubs that can eventually enhance soil fertility, reduce water loss, increase nutrient cycling, add organic matter from litterfall, and improve soil structure. The presence of shrubs may increase the productivity of associated grasses compared to shrub-free grass stands.

Natural area rehabilitation—Areas not managed for forage production, such as natural areas, should be seeded with native species. Seeding non-native species is not recommended because they may inhibit native community recovery and alter the diversity of local plant communities.

When designing a seed mix for natural areas, including wetlands, use the local native landscape as reference for species selection. Local wildland collected seed could be considered because the seeds may be well adapted to local conditions. Depending on current-year growing conditions, collected wildland seeds can sometimes have low viability. For instance, germination tests of Indian ricegrass have shown more than half the seeds lack a developed embryo and were not capable of germination. To compensate for low viability, collecting large quantities of seeds is necessary. This can increase collection time and costs unless volunteer labor is available.

Roadside rehabilitation—Roadside soil often has low fertility and depleted biological activity because of nutrient-poor construction sub-soil fill materials. These soil conditions reduce the establishment and persistence of vegetative stands and limit revegetation success. Topsoil should be added to supply nutrients, plant propagules, and mycorrhizal inocula when current soils are unfit or topsoil is missing from roadsides. If appropriate, plan a topsoil salvage and replacement operation.

STEP 7

DESIGN A SEED MIX

After construction is complete, quick application of seed is usually necessary given the likelihood of rapid invasive weed establishment along roadsides. In addition, the freshly scarified and roughened surface provides an excellent seed bed.

When selecting plant materials, consider species' ability to adapt to the site, rapidly establish, and self-perpetuate. Whenever practicable, select and distribute native species based on ecological criteria. Native grasses such as Idaho fescue (*Festuca idahoensis*), Sandberg bluegrass (*Poa secunda*), and 'Nortran' tufted hairgrass are short-growing and can significantly reduce costly roadside mowing maintenance. Also consider the species' ability to minimize soil erosion and tolerate disturbance. Rhizomatous species with extensive root systems are a good choice. For instance, streambank and thickspike wheatgrass (*Elymus lanceolatus* and *E. macrourus*, respectively) are strongly rhizomatous with excellent seedling vigor. They are frequently used for roadside erosion control, but are tall in stature and may require regular mowing. Grass-like sedges such as slenderbeak sedge (*Carex athrostachya*), dewey sedge (*C. deweyana*), and chamisso sedge (*C. pachystachya*) are demonstrating favorable results with roadside revegetation efforts in Glacier National Park, Montana.

J.S. Peterson@USDA-NRCS PLANTS Database

Idaho fescue is a native, low-growing bunchgrass. Its short stature reduces the need for mowing maintenance, making it a good choice for roadsides.

When revegetating roadsides, it is difficult to recreate a native community in its entirety. It is still valuable, however, to use species that are major components of the targeted community type. Dominant, prevalent, and "visual essence" species could be included. These include site-specific species occurring most abundantly and having some unique, visually important trait within the community. Native forbs that may satisfy this and perform well along roadsides include Pacific aster (*Symphyotrichum chilense*), lanceleaf and golden tickseed (*Coreopsis lanceolata* and *C. tinctoria*), purple coneflower (*Echinacea* spp.), Drummond phlox (*Phlox drummondii*), and hoary verbena (*Verbena stricta*). Implementing integrated roadside vegetation management practices that favor the seeded species is essential to long-term roadside revegetation success. See Appendix B for additional information on roadside rehabilitation.

QUICKLY REESTABLISH VEGETATION TO MINIMIZE EROSION

Sloped landscapes and drainages should be seeded with soil-stabilizing species. Quick-establishing annuals provide immediate protection, but only for a year. Italian ryegrass (*Lolium perenne* ssp. *multiflorum*) or small grains establish very quickly to provide rapid protection and are non-persisting. Regreen is a sterile hybrid cross of common wheat and tall wheatgrass that reduces wind and water erosion, establishes quickly, and is non-persisting. Canada wildrye (*Elymus canadensis*) and slender wheatgrass are quick establishing native grasses that are often included in seed mixtures for rapid establishment of protective cover. Slender wheatgrass is often seeded at 20 to 40 percent of the seed mix for wildfire rehabilitation.

Rhizomatous grasses and grass-like plants are ideal for long-term erosion control because of their extensive networks of soil-stabilizing underground stems and roots. 'Critana' thickspike wheatgrass, a native rhizomatous cultivar with very strong seedling vigor, is good for site stabilization in coarse soils. Blue wildrye (*Elymus glaucus*) is a native, cool-season bunchgrass commonly used in erosion-control in forested sites where rapid slope or site stabilization is needed. Pacific

STEP 7

DESIGN A SEED MIX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Hard fescue is a long-lived, non-native bunchgrass that may compete well with invasive weeds.

aster, Rocky Mountain beeplant (*Cleome serrulata*), purple coneflower, common and pale evening-primrose (*Oenothera biennis* and *O. pallida*), 'Bandera' Rocky Mountain penstemon* (*Penstemon strictus*), and lacy phacelia (*Phacelia tanacetifolia*) are native forbs that perform well in disturbed areas and may help reduce erosion. Grass-like plants such as sedges, spikerushes (*Eleocharis* spp.), rushes (*Juncus* spp.), bulrushes (*Scirpus* spp.), and cattails (*Typha* spp.) are helpful for erosion control in riparian areas. See Tables 2 and 3 for additional recommended species with soil-stabilizing characteristics.

ESTABLISH SPECIES TO MINIMIZE WEED INVASION OR REESTABLISHMENT

An effective seed mix that provides weed competition usually consists of aggressive, quick-establishing grasses and forbs. Competition-intolerant species should not be considered. Recent research suggests enhanced forb diversity may result in preferential resource use by desired species. For instance, spotted knapweed demonstrated strong performance in sites with low diversity, especially when native forbs were absent. This suggests sites with high native forb diversity might better compete with spotted knapweed. It is recommended the native forb component of plant communities be maintained or restored to maintain ecosystem stability. Once removed, forbs are difficult and expensive to reestablish.

For a plant community to be relatively "weed-resistant," it should effectively and completely utilize all available resources. Design seed mixes that include shallow- and deep-rooted forbs and grasses that grow both early and late in the year to maximize nutrient and water resource use. Cool-season species use soil resources in the upper soil profile and begin seed production in early summer. Competitive native cool season grasses include thickspike wheatgrass, slender wheatgrass, western wheatgrass, and Canada wildrye. Non-native grasses highly competitive with weeds include several cultivars with long growing seasons and extensive root systems, including pubescent wheatgrass (*Elytrigia intermedia* ssp. *trichophorum*), intermediate wheatgrass, hard fescue (*Festuca trachyphylla*), and 'Bozoisky' Russian wildrye. Solid or mature stands of meadow brome or sheep fescue, both non-native bunchgrasses,

* Care should be taken to avoid hybridization with Lehmi penstemon (*Penstemon lemhiensis*), a sensitive plant that is imperiled in Montana. Call the Montana Natural Heritage Program at **406-444-5354**, for information on recorded occurrences of this plant in your area. Avoid seeding Rocky Mountain penstemon if Lehmi penstemon occurs in your area.

STEP 7

DESIGN A SEED MIX

have demonstrated some resistance to weed invasion in certain western Montana sites.

Competitive native forbs suitable for revegetation include 'Appar' prairie flax (*Linum lewisii*), common yarrow (*Achillea millefolium*), Maximilian sunflower (*Helianthus maximiliani*), common gaillardia (*Gaillardia aristata*), and fireweed (*Chamerion angustifolium*). Lacy phacelia is an aggressive native annual with good competitive abilities. Numerous other native forbs are available and suitable for revegetation efforts.

Deep tap-rooted shrubs, such as sagebrush, can utilize resources from the lower soil profile throughout the growing season. Shrubs can be included as seeds in a mix or planted as young plants. Furthermore, shrubs may increase establishment of desired understory species by:

- ❑ Increasing water availability by intercepting water from light rains and snow.
- ❑ Increasing infiltration rate and water-holding capacity by improving soil structure.
- ❑ Enhancing soil fertility and seedbanks by concentrating nutrients and catching wind-blown soil, seeds, and mycorrhizal spores.
- ❑ Decreasing understory temperatures to reduce evapotranspiration and increase nutrient cycling.

Gary A. Monroe @ USDA-NRCS PLANTS Database

Fireweed is an aggressive, native forb that may compete well with invasive weeds.

RESTORE A HEALTHY PLANT COMMUNITY

A healthy plant community is important to sustainable invasive weed management as well as meeting other land use objectives. Developing a healthy plant community involves steadily removing weeds and replacing them with desired plants. This replacement can occur naturally, when desired vegetation is adequate within the degraded site, or through revegetation. Species selection for restoration of a desired or healthy plant community should be based on revegetation goals and objectives and specific conditions of the site.

Long-term maintenance that favors the seeded species will be necessary towards the development of a healthy plant community. The desired grass component should be managed to encourage strong vigor and growth by avoiding heavy or untimely grazing practices. The forb component should be managed to encourage the highest levels of diversity, a condition that may be promoted by periodic prescribed burning, if appropriate.

STEP 7

DESIGN A SEED MIX

NATIVE VS. NON-NATIVE SPECIES SELECTION

(Adapted in part from Harper-Lore 2000)

Many land managers interested in wide adaptability, easy establishment, forage production, and competi–tiveness with invasive weeds are shifting from seeding introduced grasses, such as crested wheatgrass (*Agropyron cristatum*) to native species to restore the genetic and ecological integrity of ecosystems. 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 seedling vigor, are also used for erosion control.

Vegetation management—Short-growing native grasses, such as Idaho fescue, sandberg bluegrass, canby bluegrass, and 'Nortran' tufted hairgrass, reduce roadside mowing maintenance.

Ecology and aesthetics—Native plants can maintain ecological stability and establish a more natural setting. A Glacier National Park study found the use of natives for roadside revegetation was preferable compared to non-natives 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. For instance, non-native crested wheatgrass can perform well in an average rainfall year, but drought in combination with other environmental conditions may severely limit its performance. Many native grasses and forbs–see Tables 2 and 4–are resilient to drought, and replacement plantings should be rare.

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'Bandara' Rocky Mountain penstemon was developed for its fibrous root system and is often included in reclamation seed mixes for its ability to control erosion. Do not plant this species if Lehmi penstemon occurs in your area. Contact the Montana Natural Heritage Program.

Many non-native grasses are competitive with invasive weeds. However, native grass species can also be effective competitors. Idaho fescue, a late-seral native bunchgrass, competes well with invasive weeds and cheatgrass on degraded sites. Thickspike wheatgrass, slender wheatgrass, western wheatgrass, and Canada wildrye are also competitive.

Table 2. Native grasses and grasslike plants recommended for western Montana revegetation projects. All are cool-season perennials unless stated.

NAME	CULTIVAR(S)	GROWTH FORM	PREFERRED SOIL TYPE	MINIMUM PRECIPITATION (INCHES)	EROSION CONTROL	PURE STAND PLS RATE/ ACRE* (POUNDS)	NOTES
BUNCHGRASSES SHORT TO SHORT-MEDIUM BUNCHGRASSES							
Idaho fescue (*Festuca idahoensis*)	Joseph, Nezphurs, Winchester	Short bunchgrass	Silty-loamy to clayey	10	Good	8	Moderately drought-tolerant. Slow establishment. Poor seedling vigor. Good palatability to wildlife and livestock.
Prairie junegrass (*Koeleria macrantha*)	—	Short bunchgrass	Sandy	12	Good	2	Drought-tolerant. Moderate establishment. Useful where early season forage is desired and erosion is not a severe problem. Tolerant of grazing.
Meadow barley[1,2] (*Hordeum brachyantherum*)	—	Short-medium bunchgrass	Silty-loamy to clayey	16	Good	15	Tolerates standing water for short periods. Palatable and saline tolerant.
Alpine timothy[2] (*Phleum alpinum*)	—	Short-medium bunchgrass	Clay	16 (or wet areas)	Good	2	Prefers poorly drained mountain meadows. Good forage for livestock and wildlife because it stays green throughout most of the summer.
Sandberg bluegrass (*Poa secunda*)	High Plains	Short bunchgrass	Sandy to clayey	8	Poor	4	Drought-tolerant. Slow establishment. Productive on poor sites.
Needle and thread (*Heterostipa comata*)	—	Short-medium bunchgrass	Sandy to silty-loamy	10	Good	14	Drought-tolerant. Long-lived. Good palatability before seed set but preferred less than other grasses. Useful for disturbed sites.
MEDIUM TO MEDIUM-TALL BUNCHGRASSES							
Mountain brome (*Bromus marginatus*)	Bromar, Garnet	Medium-tall bunchgrass	Silty-loamy to clayey	16	Very good	27	Rapid establishment, short-lived. Adapted to relatively moist soils, including thin, infertile sites. Intolerant of high water tables. Useful for soil stabilization. Good palatability.
Indian ricegrass (*Achnatherum hymenoides*)	Rimrock, Nezpar, Paloma	Medium bunchgrass	Sand to sandy	8	Good	12	Drought tolerant. Easy to moderate establishment, relatively short-lived. Useful in coarse soils on droughty, low-fertility sites. Highly palatable and nutritious. Calcium carbonate tolerant and moderately saline tolerant.
Tufted hairgrass[2] (*Deschampsia caespitosa*)	Nortran	Medium bunchgrass	Silty-loamy to clayey	20 (or wet areas)	Good	1	Most common on moist sites. 'Nortran' is used for low maintenance ground cover. Very palatable to livestock and wildlife.
Rough fescue (*Festuca campestris*)	—	Medium-tall bunchgrass	Silty-loamy to clayey	12	Good	10	Most common in prairies and open woods. Establishes on a wide variety of soil types. Excellent forage for cattle and horses; good forage for wildlife. Susceptible to overgrazing.
Bluebunch wheatgrass (*Pseudoroegneria spicata* ssp. *spicata*)	Goldar, Secar	Medium-tall bunchgrass	Silty-loamy to clayey	10	Good	12	Drought-tolerant. Moderate establishment. Adapted to most sites including thin, nonproductive soils. Highly preferred forage for livestock and wildlife.
Big bluegrass[1] (*Poa ampla*)	Sherman	Medium bunchgrass	Silty-loamy to clayey	8	Good	2	Easy establishment. Excellent palatability and stays green later than other species. Intolerant of poorly drained soils or high water tables. Tolerant of calcareous to mildly saline soils.
TALL TO VERY TALL BUNCHGRASSES							
Blue wildrye (*Elymus glaucus*)	Arlington, Elkton	Tall bunchgrass	Sandy to silty-loamy	12	Excel-lent	10	Rapid establishment, short-lived. The attractive blue-green foliage adds value to landscaping projects where slope stabilization is needed.
Canada wildrye (*Elymus canadensis*)	Mandan	Tall bunchgrass	Sandy	12	Very good	15	Rapid establishment, short-lived. Prefers moist or periodically moist, well drained sites. Good palatability, but poor grazing tolerance.
Slender wheatgrass[1] (*Elymus trachycaulus*)	Primar, Pryor, Revenue, San Luis	Tall bunchgrass	Sandy to clayey	16 (or wet areas)	Very good	12	Moderate drought tolerance. Rapid establishment, short-lived. Saline-tolerant and adapted to a wide range of sites. Useful where quick, native, non-aggressive perennial cover is desired. Suited to high elevations.
Basin wildrye (*Leymus cinereus*)	Trailhead, Magnar	Very tall bunchgrass	Silty-loamy to clayey	8	Good	11	Occurs in areas with ground moisture. Slow establishment. Adapted to a wide variety of sites in winter-wet and summer-dry areas. Good winter forage.

1. Adapted to saline-alkaline soils 2. Requires wetland/riparian habitat or performs well in standing water or periodic flooding
*High seeding rates recommended to assist establishment

Table 2. Native grasses and grasslike plants cont'd.

NAME	CULTIVAR(S)	GROWTH FORM	PREFERRED SOIL TYPE	MINIMUM PRECIPITATION (INCHES)	EROSION CONTROL	PURE STAND PLS RATE/ ACRE* (POUNDS)	NOTES
MEDIUM TO MEDIUM-TALL RHIZOMATOUS							
Streambank wheatgrass *(Elymus lanceolatus)*	Sodar	Medium-tall rhizomatous	Sandy to clayey	8	Excellent	12	Drought-tolerant. Moderate establishment, short-lived. Especially well suited for stabilizing highly erosive silty to sandy upland soils.
Mannagrass[2] *(Glyceria spp.)*	—	Medium-tall rhizomatous	Clayey	18 (or wet areas)	Good	12	Adapted to stream banks, marshes, and wet areas.
Beardless wildrye[1] *(Leymus triticoides)*	Shoshone	Medium-tall rhizomatous	Sandy	10	Very good	20	Moderately drought-tolerant. Difficult establishment. Saline-tolerant and suited for erodible, poorly drained soils. Very palatable; useful for improving saline range.
Western wheatgrass[1] *(Pascopyrum smithii)*	Rosana, Rodan, Arriba	Medium-tall rhizomatous	Silty-loamy to clay	10 (or riparian)	Moderate	16	Drought-tolerant and palatable. Fairly easy to moderate establishment, long-lived. Useful for slightly saline, erosive soils where long-lived hardy vegetation is desired and rapid establishment is not.
Beardless wheatgrass *(Pseudoroegneria spicata ssp. inermis)*	Whitmar	Medium rhizomatous	Silty-loamy	13–15	Good	12	Fair establishment, long-lived. Intolerant of poor drainage, high water tables, and spring flooding.
Spikerush[1,2] *(Eleocharis spp.)*	—	Short-medium rhizomatous	Clayey	Wet areas	Excellent	12	Easy establishment. Occurs on wet saline-alkaline soils. Useful for quick stabilization.
TALL RHIZOMATOUS							
American sloughgrass[2] *(Beckmannia syzigachne)*	Egan	Tall rhizomatous	Silty-loamy to clayey	25 (or wet areas)	Excellent	19	Annual or short-lived perennial (4–5 years) adapted to wet sites. 'Egan' developed for erosion control in seasonally wet areas.
Bluejoint reedgrass *(Calamagrostis canadensis)*	Sourdough	Tall rhizomatous	Silty-loamy to clayey	18 (or wet areas)	Very good	4	Easy establishment. Adapted to wetland and riparian sites. 'Sourdough' developed for ability to establish easily and stabilize soil. Relatively shade tolerant.
Thickspike wheatgrass *(Elymus macrourus)*	Bannock, Critana, Schwen-dimar	Tall rhizomatous	Sandy to clayey	8	Excellent	12	Drought-tolerant. Easy to fair establishment, long-lived. Good year-round palatability.
GRASSLIKE PLANTS							
Sedge[2] *(Carex spp.)*	—	Bunchgrass or rhizomatous	Clayey	Wet areas	Good	2–7	Many species. Useful for restoring wetland and riparian areas.
Arrowgrass[1,2] *(Triglochin maritium)*	—	Short-medium rhizomatous	Clayey	Wet areas	Good	5	Adapted to saline-alkaline wet areas; poisonous to livestock.
Rush[1,2] *(Juncus spp.)*	—	Short to tall rhizomatous	Clayey–clay	12 (or wet areas)	Good	12	Many species, most prefer saturated soils but can tolerate drought periods. Useful for restoring wetland and riparian areas. Unpalatable.
Bulrush[1] *(Scirpus spp.)*	—	Medium-rhizomatous	Clayey	Wet areas	Very good	20	Many species. Adapted to wet meadows, marshes, standing water, or wet muddy soils. Prefers alkaline soils.
Cattail[2] *(Typha spp.)*	—	Tall rhizomatous	Clayey	Wet areas	Good	Varies	Occurs in and around wet areas. Widely adapted and can become aggressive. Excellent cover for wildlife.
WARM-SEASON BUNCHGRASSES							
Nuttal alkaligrass[1] *(Puccinellia nuttalliana)*	Quill	Medium bunchgrass	Clayey	15 (or moist soils)	Fair	4	Valuable species for reseeding marshes, alkali basins, or other waterways. Occasionally survives in standing water.
Purple three awn *(Aristida purpurea)*	—	Short-medium bunchgrass	Sandy	10	Good	6	Easy establishment. Provides good forage before going to seed. Useful for disturbed areas.
Alkali sacaton[1] *(Sporobolus airoides)*	Salado	Medium bunchgrass	Silty-loamy to clayey	6	Fair	3	Difficult establishment. Long lived. Prefers mostly lower, slightly moist alkaline flats with high water tables (4–8 ft.) or frequent flooding. Medium palatability.
Sand dropseed *(Sporobolus cryptandrus)*	—	Medium bunchgrass	Sand to sandy	10	Very good	2	Drought-tolerant. Easy establishment. Winter hardy, with good palatability but preferred less than other grasses. Useful for rapid establishment in sandy sites. Good in a mix with slow-establishing species.
WARM-SEASON RHIZOMATOUS							
Inland saltgrass[1,2] *(Distichlis spicata)*	—	Short-medium rhizomatous	Clayey to clay	8	Poor	10	Adapted to wet, saline-alkaline sites. Useful for unusually saline areas. Often established vegetatively by sodding.

1. Adapted to saline-alkaline soils 2. Requires wetland/riparian habitat or performs well in standing water or periodic flooding
*High seeding rates recommended to assist establishment

Table 3. Non-native grasses recommended for western Montana revegetation projects. All cool-season perennials unless stated. Note: Native grasses (see Table 2) are advised when they meet revegetation goals.

NAME	CULTIVAR(S)	GROWTH FORM	PREFERRED SOIL TYPE	MINIMUM PRECIPITATION (INCHES)	EROSION CONTROL	PURE STAND PLS RATE/ ACRE* (POUNDS)	NOTES
ANNUALS							
Italian ryegrass *(Lolium perenne* spp. *multiflorm)*	Gulf	Tall annual	Silty-loamy	10	Very good	16–35	Quick and easy establishment. Highly palatable to livestock and wildlife.
Regreen (wheat x tall wheatgrass) *(Triticum aestivum* x *Thinopyrum ponticum)*	—	Medium-tall bunchgrass	Silty-loamy	12	Excellent	20–40	Annual or short-lived perennial sterile hybrid cross. Used as a soil stabilizer and cover crop. Quick and easy establishment. Does not persist or reseed. Drought-tolerant.
Triticale (wheat x cereal rye) *(Triticum aestivum* x *Secale cereale)*	Spring and winter varieties	Tall annual	Silty-loamy to clayey	12	Very good	60–100	Quick and easy establishment. Good forage production and highly palatable. Often used when maximum forage is desired while slower perennials establish.
SHORT TO SHORT-MEDIUM BUNCHGRASSES							
Hard fescue *(Festuca longifolia)*	Durar, Serra, Crystal	Short bunchgrass	Sandy to clayey	16	Very good	10	Moderately drought-tolerant. Slow but persistent establishment, long-lived. Well suited for low fertility, upland or hilly sites. Used for low-maintenance cover. Poor palatability and nutrition.
Meadow fescue[2] *(Festuca pratensis)*	—	Short bunchgrass	Sandy to clayey	18	Good	10	Slow establishment. Adapted to cool, moist regions. Useful in pasture blends and riparian areas. Extremely palatable.
Sheep fescue *(Festuca ovina)*	Covar, Quatro	Short bunchgrass	Sandy to clayey	10	Very good	10	Drought-tolerant. Slow but persistent establishment. Provides excellent and attractive ground cover. 'Covar' is an aggressive competitor. Poor palatability to livestock, but used by wildlife.
MEDIUM TO MEDIUM-TALL BUNCHGRASSES							
Perennial ryegrass *(Lolium perenne)*	Tetraploid	Medium-tall bunchgrass	Silty-loamy to clayey	12	Very good	15–35	Rapid establishment, short-lived. Useful for pasture and range improvement. Excellent palatability.
TALL TO VERY TALL BUNCHGRASSES							
Tall wheatgrass[1] *(Thinopyrum ponticum)*	Alkar, Jose, Orbit	Very tall bunchgrass	Silty-loamy to clayey	12	Good	10–17	Drought-tolerant. Easy establishment. Suitable for most saline sites and some subirrigated cases. Low palatability.
Tall fescue[1] *(Lolium arundinaceum)*	Alta, Fawn, Kenmont, Goar	Tall bunchgrass	All soils except sandy	18	Good	8	Slow establishment. Long-lived. Tolerates wet, poorly drained sites. Useful for pasture with good palatability Relatively tolerant of heavy grazing.
Altai wildrye[1] *(Leymus angustus)*	Prairieland, Pearle, Eejay	Tall bunchgrass	Silty-loamy to clayey	18	Very good	15	Slow establishment. Extremely saline- and alkaline-resistant.
Russian wildrye[1] *(Psathyrostachys juncea)*	Bozoisky, Swift, Mankota, Vinall	Tall bunchgrass	Silty-loamy to clayey	12	Poor	7–10	Drought-tolerant. Difficult establishment, long-lived. Useful for somewhat saline sites where severe erosion is not a problem. Palatability and nutrition are excellent year-round. Well suited as a pasture grass. Not adapted to cool, moist sites.
MEDIUM TO MEDIUM-TALL RHIZOMATOUS							
Meadow brome[1] *(Bromus biebersteinii)*	Regar, Fleet, Paddock, McBeth, Montana	Medium weakly rhizomatous	Silty-loamy to clayey	16 (or irrigated)	Good	12–17	Good drought tolerance. Easy establishment, long-lived. Very productive: Starts growth in early spring, ripens by early summer and produces abundant late-summer and fall regrowth. Highly palatable when green. Excellent winter hardiness.
Orchardgrass *(Dactylis glomerata)*	Many	Medium-tall rhizomatous	Silty-loamy to clayey	16 (or irrigated)	Good	8	Easy establishment, medium-lived. Adapted to a wide variety of sites. Highly productive and palatable, grazing tolerant. 'Paiute' was selected for its drought hardiness.
Newhy hybrid wheatgrass[1] *(Elymus hoffmanii)*	Newhy	Medium weakly rhizomatous	Silty-loamy to clayey	10	Good	14	Easy establishment. Adapted to moist soils including moderately saline sites. Useful on both irrigated and non-irrigated pasture.
Intermediate wheatgrass *(Thinopyrum intermedium)*	Amur, Greenar, Oahe, Tegmar, Rush	Tall rhizomatous	Silty-loamy to clayey	14	Excellent	10–12	Moderately drought-tolerant. Easy establishment, medium-to long-lived. Sites should not be subject to prolonged drought or severe combinations of extreme cold and lack of snow cover.
Pubescent wheatgrass[1] *(Elytrigia intermedia* spp. *trichophorum)*	Greenleaf, Luna, Manska, Topar	Tall rhizomatous	Sandy to clayey	12	Very good	12–14	Moderately drought-tolerant. Easy establishment, long-lived. Well suited for stabilizing slightly saline soils. Not winter hardy; use is limited to less harsh sites.
WARM-SEASON GRASSES							
Sudangrass *(Sorghum bicolor* spp. *drummondii)*	Many	Medium-tall bunchgrass	Silty-loamy to clayey	14	Good	30 –50	Annual grass that prefers warm and moist soils. Often used in stubble mulch crops.

1. Adapted to saline-alkaline soils 2. Requires wetland riparian habitat or forms well in standing water or periodic flood irrigation
*High seeding rates recommended to assist establishment

Table 4. Selected forbs and shrubs for western Montana revegetation projects. All native unless stated.

NAME	CULTIVAR(S)	SOIL TYPE	MINIMUM PRECIPITATION (INCHES)	PURE STAND PLS RATE/ ACRE* (POUNDS)	NOTES
ANNUAL FORBS					
Indian paintbrush[1] *(Castilleja spp.)*	—	Clayey	12	1	Prefers wet, saline or alkaline meadows. Recommended for sites with high water tables and heavy soils.
Rocky Mountain beeplant *(Cleome serrulata)*	—	Silty-loamy to clayey	16	10–16	Recommended for short-term stabilization in disturbed areas. Attracts bees and butterflies.
Golden tickseed *(Coreopsis tinctoria)*	—	Silty-loamy	12	2	Drought-tolerant. Blooms June to September. Found along roadsides, fields, and meadows.
Annual phlox *(Phacelia tanacetifolia)*	—	Silty-loamy	10	2–8	Aggressive growth and adapted to a wide range of soils. Good for erosion control.
Drummond phlox *(Phlox drummondii)*	—	Silty-loamy	12	6–8	Blooms May to October in fallow fields, open woods, roadsides, and prairies.
PERENNIAL SHORT PERENNIAL FORBS					
Sulfur-flower *(Eriogonum umbellatum)*	—	Sandy to silty-loamy	10	4–7	Drought-tolerant. Common on dry rocky slopes, and mountain meadows. Requires well drained soils.
Pale evening-primrose *(Oenothera pallida)*	—	Sandy to silty-loamy	12	4	Blooms May to September, good erosion control.
MEDIUM PERENNIAL FORBS					
Common yarrow *(Achillea millefolium)*	—	Sand to sandy	10	1	Drought-tolerant and aggressive. Used for erosion control and landscaping. Useful to wildlife. Not palatable to livestock.
Columbine *(Aquilegia spp.)*	—	Sandy to clayey	16	3–7	Moderate to high moisture requirements. Most species bloom June to August.
Butterfly milkweed *(Asclepias tuberosa)*	—	Sandy to silty-loamy	24	7–12	Drought-tolerant. Showy perennial that attracts butterflies. Blooms June to September.
Pacific aster *(Symphyotrichum chilenes)*	—	Sandy to clayey	12	2	Somewhat drought-tolerant. Blooms July to October. Often found in disturbed areas. Good erosion control.
Arrowleaf balsamroot *(Balsamorhiza sagittata)*	—	Silty-loamy	12	7–15	Drought-tolerant. Blooms May to July on open hillsides, grasslands, and in open pine forests. Provides valuable spring forage for deer and elk.
Aspen fleabane *(Erigeron speciosus)*	—	Sandy to silty-loamy	16	1	Blooms June to September. Found along open moist slopes, along streams, and under aspens, spruce and fir.
Common gaillardia *(Gaillardia aristata)*	—	Sandy to silty-loamy	10	6–10	Fairly drought-tolerant and suitable for use in mixtures for erosion control.
Boreal sweetvetch *(Hedysarum boreale)*	—	Silty-loamy	14	15–25	Drought-tolerant and productive. Palatable to wildlife and livestock.
Prairie flax *(Linum lewisii)*	Appar	Sandy to silty-loamy	10	5	Drought-tolerant. Easy establishment, short-lived. Adapted to well drained soils. 'Appar' has outstanding vigor and competitiveness.
Common evening primrose *(Oenothera biennis)*	—	Sandy	14	2	Blooms July and August. Found in disturbed areas. Good for erosion control.
Prairie coneflower *(Ratibida columnaris)*	Stillwater	All types	16	2	Drought-tolerant, showy species common on gentle slopes, roadsides and grassy prairies, especially on well drained limestone soils. Good nutrition and medium palatability to livestock.
☛NON-NATIVE Small burnet *(Sanguisorba minor)*	Delar	Silty-loamy	10	20–24	Easy establishment, long-lived. 'Delar' is winter hardy, moderately drought-tolerant. Valuable forage for livestock and wildlife in late winter and early spring.
Munro's globemallow *(Sphaeralcea munroana)*	—	Sand to sandy	12	4–8	Drought-tolerant. Blooms May to August along roadsides, sandy washes, abandoned fields, and other exposed areas.
Mountain goldenbanner *(Thermopsis montana)*	—	Silty-loamy	16	20–40	Blooms May to August in meadows and moist woods or along streams. Persists on wet soils or sites that are wet early but dry out in summer.
Mule-ears *(Wyethia amplexicaulis)*	—	Silty-loamy to clayey	14	16	Drought-tolerant. Occurs on rangeland, hillsides, open woods, dry meadows and moist draws. Blooms May to July.
Rocky Mountain iris[2] *(Iris missouriensis)*	—	Silty-loamy to clayey	16	15–30	Useful where moisture is plentiful. Poisonous to livestock.
Prairie sage *(Artemisia ludoviciana)*	Summit	Sandy to silty-loamy	10	(Varies)	Rhizomatous forb adapted to a wide variety of soils from 2,500 – 9,000 ft. Establishes quickly and easily, even on harsh sites.

1. Adapted to saline-alkaline soils 2. Requires wetland riparian habitat or forms well in standing water or periodic flood irrigation
* Seeding rate for pure stands; forbs and shrubs are most commonly planted as a mixture component rather than a pure stand; see Step 9.

Table 4. Selected forbs and shrubs cont'd.

NAME	CULTIVAR(S)	SOIL TYPE	MINIMUM PRECIPITATION (INCHES)	PURE STAND PLS RATE/ ACRE* (POUNDS)	NOTES
TALL PERENNIAL FORBS					
Lanceleaf tickseed *(Coreopsis lanceolata)*	—	Sandy to silty-loamy	14	8–10	Blooms May to August. Prefers sandy or rocky soil. Establishes well on disturbed sites. Uses include roadside or waste area plantings.
Purple coneflower *(Echinacea spp.)*	—	Silty-loamy	12	7–12	Fairly drought-tolerant. Establishes on wide range of soil types. Commonly included on roadsides for erosion control and beautification.
Fireweed *(Chamerion angustifolium)*	—	Silty-loamy	8	0.5	Blooms June to September. Occurs in rich moist soil in open woods, prairies, hills, along streams and disturbed ground. Aggressive and persistent.
Sticky purple geranium[2] *(Geranium viscosissimum)*	—	Silty-loamy	14	10–12	Prefers moist meadows, along streams, or open slopes at mid to high elevations.
Maximilian sunflower *(Helianthus maximiliani)*	—	Silty-loamy to clayey	14	6–10	Moderate drought tolerance. Moderate ease of establishment. Rhizomatous and very competitive.
Rocky Mountain penstemon *(Penstemon strictus)*	Bandera	Sandy to silty-loamy	14	3–4	Blooms May to June. Widely adaptable. Fibrous root system and ability to persist on rocky or sandy loam sites. To avoid hybridization, not recommended in areas with Lemhi penstemon *(P. lemhiensis)*, a sensitive plant imperiled in MT.
Purple verbena *(Verbena stricta)*	—	Silty-loamy	12	4–6	Drought-tolerant. Blooms June to September. Grows in exposed areas. Used for roadside stabilization.
LEGUMES					
☛ NON-NATIVE Cicer milkvetch *(Astragalus cicer)*	Lutana, Windsor, Monarch, Oxley	Silty-loamy	18	20–25	Fair drought tolerance. Slow establishment, long-lived. Cold hardy. Performs well on poor, infertile soils. Useful for erosion control and as a nonbloat forage and hay mix.
☛ NON-NATIVE Birdfoot trefoil[1] * *(Lotus corniculatus)*	Empire, Viking	Silty-loamey to clayey	15	6	Slow establishment, long-lived. Adapted to wet and poorly drained sites; cold hardy; alkaline- and saline-tolerant. Useful for erosion control and as a nonbloat forage. Grows best alone and not in mixes.
Lupine *(Lupinus spp.)*	—	Silty-loamey to clayey	12–16	10–24	Generally found on dry, open, or shaded sites.
Alfalfa[§] *(Medicago spp.)*	Many	Silty-loamy	12	15	Fair drought tolerance. Easy establishment. Widely used for pasture.
☛ NON-NATIVE Sainfoin[1] *(Onobrychis viciaefolia)*	Eski, Remont, Melrose	Silty-loamy	12	35–45	Drought-tolerant. Easy establishment, short-lived. Typically used in pasture mixes for short rotations. Highly palatable, nonbloat, winter hardy, and alkaline tolerant.
Prairie clover *(Dalea spp.)*	Kaneb	All types	14	6–8	Long-lived. White prairie clover *(D. candida)* is an excellent legume for erosive sites where productive, palatable, nutritious forage is desired. 'Kaneb' purple prairie clover *(D. lasiathera)* has superior vigor, height, and stand development.
☛ NON-NATIVE Alsike clover [1] *(Trifolium hybridum)*	Tetraploid or diploid	Clayey	32	8	Moderate ease of establishment, short-lived. Adapted to cool and moist sites. Cold hardy and shade intolerant. Tolerates alkalinity more than other clovers. Used in hay and pasture.
Vetch *(Vicia spp.)*	Lana	Silty-loamy	12–18	40	Easy establishment, most short-lived. Winter vetch *(V. villosa)* is a drought-tolerant annual. Highly palatable and nutritious.
SHRUBS SMALL SHRUBS					
Fringed sagewort *(Artemisia frigida)*	—	Silty-loamy	6	(Varies)	Attractive sub-shrub occurring from 3,000 – 8,000 ft, usually on thin, dry soils.

1. Adapted to saline-alkaline soils 2. Requires wetland/riparian habitat or performs well in standing water or periodic flooding
* Seeding rate for pure stands; forbs and shrubs are most commonly planted as a mixture component rather than a pure stand; see Step 9
§Request a copy of the Extension MontGuide, "Alfalfa Variety Selection," Publication No. MT199303

Table 5. Recommended native grasses for western Montana by zone (adapted from Wiersum et al. 2000)

ZONE 1 : DRY, WARM SITE *Open grasslands and woodland benches, at low elevations on all aspects and on south–and west-facing slopes at higher elevations (this zone is usually susceptible to weed invasion)*	**Pure stand broadcast, pure live seed rate (PLS) (lbs/ac at 40 seeds/sq ft)**
NATIVE GRASSES	
Slender wheatgrass	12
Thickspike or streambank wheatgrass	12
Bluebunch wheatgrass	12
Beardless wheatgrass	12
Big bluegrass	2
Canada wildrye	15
NATIVE TREES AND SHRUBS	
Trees: Ponderosa pine-west, Douglas fir-west; Shrubs <4´: snowberry, woods rose, bitterbrush, skunkbush sumac; Shrubs >4´: mountain mahogany, mockorange, chokecherry	

ZONE 2 : MOIST, WARM SITE *Moderate environments receiving more precipitation than dry, warm sites. Found on north-and east-facing slopes on lower elevation, all aspects at mid-elevations, and on south- and west-facing aspects at higher elevations*	**Pure stand broadcast, PLS rate (lbs/ac at 40 seeds/sq ft)**
NATIVE GRASSES	
Slender wheatgrass	12
Thickspike or streambank wheatgrass	12
Beardless wheatgrass	12
Big bluegrass	2
Mountain brome	27
Canada wildrye	15
NATIVE TREES AND SHRUBS	
Trees: Ponderosa pine-west, Douglas-fir-west, western larch; Shrubs <4´: snowberry, Woods rose, currant; Shrubs >4´: serviceberry, Rocky Mountain maple	

ZONE 3: MOIST, COOL SITE *Found predominately on north- and east-facing slopes at mid-elevations and on all aspects at high elevations*	**Pure stand broadcast, PLS rate (lbs/ac at 40 seeds/sq ft)**
NATIVE GRASSES	
Slender wheatgrass	12
Beardless wheatgrass	12
Big bluegrass	2
Tufted hairgrass	1
Mountain brome	27
NATIVE TREES AND SHRUBS	
Trees: Douglas-fir-west, western larch, Engelmann spruce; Shrubs >4´: Scouler's willow, red-osier dogwood, alder, Rocky Mountain maple	

ZONE 4 : RIPARIAN AREAS *Stream bottoms, wet meadows: these sites are subirrigated for at least a portion of each growing season*	**Pure stand broadcast, PLS rate (lbs/ac at 40 seeds/sq ft)**
NATIVE GRASSES	
Slender wheatgrass	12
Western wheatgrass	16
Tufted hairgrass	1
GRASSLIKE PLANTS	**Plugs/ac**
Native sedges	11,000
Native rushes	11,000
NATIVE TREES AND SHRUBS	
Trees: black cottonwood, quaking aspen, Engelmann spruce; Shrubs <4´: snowberry, Woods rose; Shrubs >4´: native willows, red-osier dogwood, chokecherry, mockorange, Rocky Mountain maple, water birch, alder, serviceberry	

STEP 8

DETERMINE A SEEDING OR PLANTING METHOD

The most common seeding methods are drilling, broadcasting, and hydroseeding. Hay mulch seeding is less common. Island planting, plugging, and sprigging place whole plants or rhizomes in the soil. The seeding method depends on site accessibility and terrain, seedbed characteristics, species and seed characteristics, and economic constraints.

Drill seeding controls seeding rates and promotes germination by placing seeds at specific soil depths.

DRILL SEEDING

A non-rocky site 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 enhances seedling establishment since seed depths and seeding rates are controlled and seed-to-soil contact is high. Ideal native seeding depths range from 1/4 inch for small seeds to about 1/2 to one inch for large seeds. Seeding depth varies with site characteristics that influence soil moisture. Chief among them are soil texture, site exposure, and aspect. Although drill seeding can enhance seedling establishment, some shortcomings are recognized:

- ❑ The plants that germinate develop in rows resembling a crop rather than a native plant community. This can be avoided by seeding in two perpendicular passes.
- ❑ Long, narrow seeds are difficult to plant because they become bridged within the drill.
- ❑ Some species require shallow placement in the soil while others require deeper placement. Therefore, two separate seeding operations may be needed when planting a mix. Or more than one seed box may be needed on the drill so drop tubes can be pulled to broadcast seed on the ground.
- ❑ Seeds of various sizes will separate in the seed container. Small seeds vibrate to the bottom of the seed box and fall faster than larger seeds. Adding a carrier such as cracked corn or rice hulls, or vermiculite or perlite, can mitigate the size or weight segregation of seeds. Adding a carrier also controls the flow of problematic seeds with long awns, like needle-and-thread.
- ❑ Drill furrows can cause soil erosion from water flow unless seeding is performed along the slope contour.

BROADCAST SEEDING

Broadcast seeding is commonly used on steep, rocky, or remote sites that are inaccessible to equipment. Aircraft can seed inaccessible areas. Small areas can be seeded with a hand spreader, whereas large commercial spreaders can seed substantial areas.

Seedbed preparation is recommended prior to broadcast seeding. On accessible sites, dragging small chains or harrowing can roughen and loosen the soil surface. Roughening creates seed-safe sites, ensuring proper seed placement for establishment. Roughen the soil surface again following seeding and, if possible, lightly roll or pack the soil. The addition of hydromulch over broadcast seed can assist establishment.

Imprinting uses heavy textured rollers to make imprints in the soil surface, aiding water infiltration and soil aeration. The imprints work as small catchbasins, enhancing water accumulation for improved seed germination. Imprinting can be used in conjunction with broadcast seeding. Large seeds 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 splash erosion covers seed in the depressions without burying them too deeply in the soil. Imprinters fitted with seed bins can be stand-alone seeding devices. Imprinting is not frequently used in western Montana.

If seedbed preparation is not possible, doubling or tripling the broadcast seeding rate appropriate for drill seeding or plowed-ground seeding will ensure an adequate amount of seeds find safe sites for germination. Consider short-term livestock trampling so hoof action can push the seeds into the soil.

HYDROSEEDING

Hydroseeding is a form of broadcast seeding in which the seeds are dispersed in a liquid under pressure. The hydroseeder consists of a water tanker with a pump and agitation device to apply the seed under pressure in water that may include mulch or other additives. Sometimes germination and establishment results are less satisfactory than drill or broadcast seeding since the seed does not always make good seed-to-soil contact. Hydroseeding onto a freshly roughened or disturbed site, however, can provide appropriate seed-to-soil contact. Hydroseeding is usually the only practicable method for seeding slopes 3:1 or steeper.

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. However, since each species may produce seed at slightly different times, some species can be absent from a hay harvest. Hay should be cut when the important species are at an optimal stage of maturity and spread during the best seeding time for the dominant or preferred species within the hay. Spreading hay by hand is practicable on small sites, but chopper-shredders that shred and apply the hay are appropriate for larger sites. To avoid loss to wind, hay can be crimped into the soil with machinery, pushed into the soil by livestock trampling, or held down upon the soil with an organic tackifier. Always make sure the hay is weed-free.

ISLAND PLANTING

Planting nursery stock can complement reseeding and increase the chances of revegetation success with rapid plant establishment. Planting also circumvents the susceptible germination and establishment stages. Purchased stock can be costly. But planting fewer individuals in "islands" where central, established stands of plants can reproduce and eventually spread may reduce costs. The results of such islands will be long-term. An immediate increase in the number of non-seeded species should not be anticipated.

Areas can also be "island seeded" by drill or broadcast sowing wide strips. Over time, the seeded strips will spread into the unseeded areas. Monitor for weeds in the unseeded areas.

PLUGGING

Establishing wetland/riparian plants from seeds is difficult because site hydrology must be carefully controlled and precise amounts of heat, light, and water are needed. Broadcast seeding of wetland/riparian species is used not as a primary means of revegetation, but as a method to increase overall species diversity. Experts note planting plugs is preferred to broadcast-seeding or collecting wildlings (plants collected from wild populations). Plugs should be planted on 18- to 24-inch centers, or about 11,000 plugs per acre. The plants will spread into the unplanted areas over time.

Plugs have been successfully planted from April through late October in Idaho. Spring planting is generally preferred over fall planting since the plugs will have a longer establishment period. Fall planting may result in lower establishment because of the shorter growing season and damage from frost heaving. Wetland/riparian plants require warm temperatures, long days, and ample water. June may be the best time to plant plugs in Montana.

J. Chris Hoag @ USDA-NRCS

In riparian areas, greenhouse-grown plugs have a much higher establishment rate than straight seeding.

SPRIGGING

Sprigging involves planting rhizomes at a depth of three to four inches. Specialized equipment for digging and planting sprigs is commercially available. Plants can be established by sprigging at slightly higher salinity levels than by seeding because the rhizomes are more salt-tolerant than seedlings and can be placed below the highest concentration of salts in the soil profile. Rhizomatous grasses will continue to spread once established. The lack of an available sprig source and equipment are the main limitations to this method.

STEP 9

CALCULATE SEEDING RATE

Depending on the species, seeding rates are usually 20 to 50 viable seeds per square foot. The actual rates vary depending on many factors. These include weed interference, differences in seedling vigor, site conditions, and the components of a seed mix. When a species is used as a component of a mix, adjust to the percent of mix desired (see example below). When a species is desired as a pure stand, use the recommended amount of pure live seed (PLS) found in Tables 2 through 5. Consider increasing rates 30 percent for non-irrigated sites, doubling rates when seeding a severely burned area (80 seeds/ft^2 for perennial grasses), and doubling or tripling rates if broadcast or hydroseeding. Increasing seeding rates adds expense to a project, but may ensure establishment and increase the chances of long-term revegetation success.

Pure live seed is a measure describing the percentage of a quantity of seed that will germinate; PLS equals the percent purity multiplied by percent germination. Multiply 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:

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 PLS content 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 seed lot B is the better value at $1.97 per PLS pound; seed lot A costs $2.22 per PLS pound. Precise ordering of seed based on PLS helps purchasers 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 demonstrates the calculation of seeding rates for mixed seed.

Bluebunch wheatgrass is a native bunchgrass. It is a good choice for many revegetation projects because it has high forage value and adapts to most sites.

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GIVEN:

Of the desired seed mix, 85 percent will be bluebunch wheatgrass. This lot of seed has a 90 percent PLS. The recommended seeding rate is 12 lbs. The remaining 15 percent of the mix will be small burnet. This lot of seed has an 85 percent PLS. The recommended seeding rate is 20 lbs. PLS per acre. Thus—

(Bluebunch 85 percent) x (12 lbs. PLS/acre) = 10.2 lbs. PLS/acre mixed

(Small burnet 15 percent) x (20 lbs. PLS/acre) = 3.0 lbs. PLS/acre mixed

SOLUTION:

Bluebunch: 10.2 PLS/90 percent PLS = 11.3 lbs. bulk mixed/acre

Small burnet: 3.0 lbs. PLS/85 percent PLS = 3.5 lbs. bulk mixed/acre

STEP 10

PLANTING MATURE PLANTS

Planting mature plants circumvents germination and establishment. Planting can complement reseeding and increase the chances of revegetation success with rapid plant establishment. Local ecotypes can be obtained as salvaged, locally collected, or containerized plants propagated from seeds. Sometimes planting is the only feasible method of establishing certain plants. Seeds of many shrubs, for instance, may germinate only occasionally, establish poorly, or grow slowly under natural conditions.

Although sometimes difficult to attain, successful transplantation of salvaged or locally collected native plants may preserve local native gene pools and ecotypes. Propagation by seeds in containers, however, can attain the same purpose and has demonstrated better success. Planting bareroot stock could be considered, but may demonstrate lower survival rates compared to container-grown plants.

To increase planting success and reduce weed interference, plant during late winter or early spring. Planting during dormant periods helps plants withstand planting rigors and increases the chances adequate moisture will be available during the onset of active growth. If planting during the growing period, water at the time of transplanting and consider occasional, but temporary short-term watering. Also consider adding finished compost during planting to reduce transplant shock and increase plant survival, especially on lower-fertility, dry, or sandy soils.

Some plants tolerate transplanting better than others. Rough fescue (*Festuca campestris*), a native bunchgrass, can usually tolerate transplanting. Native plants growing in disturbed areas have been found to be sometimes well suited for transplanting. These may include purple threeawn (*Aristida purpurea*), Pacific aster, Rocky Mountain beeplant, lanceleaf tickseed, fireweed, and common and pale evening-primrose. Plants with taproots and extensive root systems may be least likely to tolerate transplanting.

Planting fewer individuals in islands where a central, established stand of plants can reproduce and spread can reduce time, effort, and costs of planting. Island planting containerized shrubs can complement a revegetated site and may increase establishment of understory species.

Marijka Wessner

Salvaging and transplanting native plants can complement revegetation and promote native plant conservation.

Planting greenhouse-grown plugs in wetland/riparian areas have a much higher establishment rate than straight seeding and spread faster and further than transplanting wildlings, or plants collected from wild populations. Transplanting wetland plants, however, which may be done successfully because of their sturdy root systems, may be considered a useful revegetation method in some cases. Consider transplanting wildlings when the plants are easy to propagate by adventitious roots or sod and when they are small. Make sure the wildlings are placed in a wet, low water stress environment. When removing wetland plants, dig no more than 14 inches of plant material from a 4-foot, 2-inch area and do not dig deeper than 5 or 6 inches. Leaving the soil on the removed plants ensures the mycorrhizae remain intact.

STEP 11

DETERMINE THE BEST TIME TO REVEGETATE

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Indian ricegrass is a native bunchgrass that requires cold stratification to break dormancy. This can be provided with a fall-dormant seeding.

The right time to seed depends on the species being seeded and the soil texture. Warm-season species are commonly seeded during late spring or early summer. Warm-season plants initiate growth in early summer. Fall-dormant seedings are common with cool-season species or when mixtures of grass, legumes, forbs, and shrubs are used. Cool-season species predominate in western Montana.

Dormant seedings should occur after the soil temperature has fallen below 55° F for one to two weeks. This period is usually during late fall (late October/early November), just before the soil freezes when temperatures and moisture remain low enough to prevent germination. Dormant seedings are important for many cool-season species that require cold stratification. For example, Indian ricegrass needs exposure to at least 30 days of cold soil to meet stratification requirements. When conditions are not adequate for a fall-dormant seeding, early spring seedings may capitalize on late snows and early rains. Planting tree and shrub seedlings should be done during early spring dormancy. Plant greenhouse-grown plugs in wetland/riparian areas during June, when warm temperatures, long days, and adequate water prevail. Seeding directly into the ash layer immediately after a fire is the best time to seed burned areas.

Soil texture can influence the timing of seeding. 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. Generally, a late fall-dormant seeding is best for cool-season species regardless of soil texture.

Late summer planting—prior to mid-August—of cool-season species should 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.

STEP 12

ASSIST ESTABLISHMENT

Seedling establishment is the most critical phase of revegetation. Many factors can influence establishment including variations in soil properties, site exposure, and climate. Seedlings usually fail to establish from a combination of factors. The most predominant are insufficient soil moisture and intense weed competition.

Enhance establishment and seedling survival with the following methods when appropriate:

- ❑ Use species adapted to local site conditions.
- ❑ Use high quality, certified seed.
- ❑ Reduce weed competition through management (see Step 6), 'Single entry' revegetation, or nutrient reduction with cover crops when planting native species with low nutrient requirements, such as bluebunch wheatgrass.
- ❑ Inoculate legume seed with proper bacteria to ensure maximum nitrogen fixation in sites lacking a healthy nitrogen cycle. This will improve nutrient uptake, water transport, drought tolerance, and resistance to pathogens.
- ❑ Place seeds in contact with the soil using a drill seeder. Or prepare a seedbed before broadcast seeding and lightly pack the soil. Also consider applying hydromulch following broadcast seeding.
- ❑ If the site is not accessible to equipment, increase seeding rate to increase the chances for an adequate amount of seeds finding safe sites. Increasing seeding rates may also improve desired species competition with invasive weeds.
- ❑ Use a land imprinter 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 as the sides of the depressions slough off and trap wind-blown particles.
- ❑ Plant plugs to establish wetland/riparian plants. Planting with plugs results in higher establishment rates, as well as faster and further spread, compared to revegetation with seeds or wildlings.
- ❑ Avoid covering wetland/riparian seeds with soil, as heat and light are needed for proper germination.
- ❑ Adding small amounts of water to temporarily encourage establishment, but only in cases when natural precipitation has proved inadequate. (An initial watering is recommended, however, after transplanting during the growing season.) Frequent watering may result in poor plant adaptation and only short-term success once supplemental water is withdrawn. Supplemental watering may stimulate germination, but will have little lasting, long-term effect. Consider using commercial water-holding polymers during establishment to provide young plants with moisture.
- ❑ Defer grazing with fencing or herding until vegetation is well established, usually after two growing seasons. If palatable slow-maturing shrubs are recovering, do not graze until the shrubs produce viable seeds.

Treating seeds can also enhance establishment. Consider the following seed treatments when appropriate.

- ❑ Seed priming starts germination, allows it to progress to a certain point, and then suspends it. The primed seeds are then ready to continue germination in the field when conditions are favorable. Seed priming is helpful with revegetation of weed-infested sites since the first seedlings to capture available resources have a competitive advantage.
- ❑ Seed fungicide protects seeds from soil-borne pathogens, which can reduce germination and seedling survival when soil moisture and surface humidity increase following rainfall. Consider this treatment in wet environments, especially with slow germinating forbs.
- ❑ Seed stratification "fools" seeds into germinating by mimicking environmental conditions. Many upland plants, such as beardless wildrye and Indian ricegrass, need cold stratification to break dormancy and germinate. There are many dormancy types and dormancy breaking strategies.
- ❑ Seed scarification breaks the seed coat with acid or through mechanical means. Seeds with considerable dormancy—Indian ricegrass, beardless wildrye, boreal sweetvetch (*Hedysarum boreale*), and prairie clover (*Dalea* spp.) among them—can benefit from this treatment.
- ❑ Seed coating involves applying a layer of material around the seed. This material may contain fertilizer, growth regulators, pesticide, or mycorrhizal fungi.

STEP 12

ASSIST ESTABLISHMENT

MULCHING

A mulch cover protects soil and seeds from wind and water erosion, conserves soil moisture, and moderates soil temperatures to improve the chances of germination and establishment success.

Hay mulch–Native certified weed-free hay is a beneficial mulch because it contains a small amount of nitrogen from leaves, flowers, and seed heads. Native hay may also contain seeds of native plants, whereby volunteer stands may develop and produce more diverse communities. Native hay harvests typically include needle and-thread, western wheatgrass, and bluebunch wheatgrass. When attempting to sow needle-and-thread, the long awns can prove problematic. But these long awns become useful appendages in hay mulches by working the seeds into the ground, improving germination. Mulches are used for short-term protection on moderate to flat slopes. Use enough hay to completely cover the soil. Pliable mulch can be crimped into the soil or briefly trampled by livestock to keep from losing it to the wind. Another option is to use an organic tackifier, which is a glue that breaks down into natural byproducts.

Stubble mulch crops–Sterile forage sorghums or millets are planted the growing season prior to the desired species seeding. After crop maturation, native seeds are sown into the residual standing dead material. Standing stubble improves soil moisture during germination by trapping snow.

C*ompanion crops*–Fast-growing, non-persisting annuals or short-lived native perennials are seeded with perennial grasses to protect soil and the young, slower establishing perennial seeded grasses. These include mountain brome, slender wheatgrass, Canada wildrye and blue wildrye, or non-native perennial ryegrass (*Lolium perenne*). Sterile hybrids such as Regreen and Triticale were developed specifically for use as cover or companion crops. They establish rapidly, do not persist or reseed into successive years, and are completely out-competed by the seeded species. Triticale is often used as a companion crop when maximum forage is desired while slower-developing perennials establish. Avoid using cereal rye as a companion crop, as it is very competitive and may spread to surrounding sites.

Reduce weed competition to assist establishment of seeded species. This spotted knapweed infestation could be weakened with sheep or goat grazing over a period of time followed by a herbicide treatment each fall.

Hydromulch–Hydraulic mulch is comprised of virgin wood fibers or recycled paper mixed into a water slurry and sprayed onto the ground. Long wood fibers intertwine with one another to form a rigid bond. Applying a tackifier with hydromulch provides excellent erosion control. Recycled paper mulch decomposes quickly and gives good protection on relatively flat slopes. It is particularly useful 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 by seedling shoots.

Erosion control blankets–These blankets are usually composed of woven organic material such as straw or coconut fiber. They are designed to allow seed germination and to permit stems to grow through and above the mat. Increase seeding rates if light-dependent species are being sown under blankets or mulch. As the fabric ages it becomes incorporated into the soil and decomposes. Mats are expensive but very effective. For steep slopes (3:1 and greater) that require long-term protection, they are sometimes the only viable option.

STEP 13

MONITOR SUCCESS

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

- ❑ Unexpected changes that shift species composition or abundance (see "Understanding Succession to Direct Successful Revegetation," page 18).
- ❑ The invasion or reestablishment of weeds from an existing seedbank.
- ❑ Preferential foraging by wildlife or livestock.
- ❑ Erosion that damages plant materials and the soil base.
- ❑ Small areas of revegetation failure.
- ❑ Unfavorable moisture.

Monitoring can identify and rectify these problems in time to allow for successful revegetation, such as:

- ❑ Reducing weed interference before, during, and after seeded species establishment. The first year or two of a project may be entirely dedicated to weed management if the site is moderately to heavily infested with invasive weeds.
- ❑ Erecting protective fencing to mitigate selective grazing by local wildlife and livestock.
- ❑ Using mulch to protect seeds, prevent soil erosion and conserve soil moisture.
- ❑ Repairing small areas of failure with new seedings or plantings and mulch.
- ❑ Providing temporary water until seedlings are established when adequate precipitation is lacking. Then, if the species were properly matched to site conditions, the plants should continue to develop on their own.

Monitoring can range from quick visual inspection to an in-depth study of species composition, distribution, and density. Monitoring frequency will depend on project goals and site conditions. A site prone to low moisture, high erosion, or weed invasion should be monitored frequently. Many native species germinate and establish slowly.

Significant results of a seeding project may take three to five years as perennial grass and forb seed often lies dormant in the soil until climate conditions are appropriate for germination.

It is important to monitor revegetated sites. This site is prone to low moisture, high erosion, and weed invasion and should be frequently monitored to increase the likelihood of revegetation success.

STEP 14

LONG-TERM MANAGEMENT

Long-term revegetation success requires continuous monitoring and evaluation for timely adjustments to maintain the desired plant community. Money and effort spent on revegetation will be wasted unless management practices favor the seeded species. Long-term maintenance includes frequently monitoring the site and adjacent areas to detect and eradicate new weeds early. Long-term maintenance also avoids heavy grazing to promote desired seed to set and disperse. This will perpetuate and maintain stands.

Encourage seeded species growth and vigor to extend the productive life and economic returns of seeded pastures. This also limits resources for invasive weed establishment and growth. A grazing management plan should be designed to encourage desired species. For instance, Indian ricegrass is highly palatable and nutritious and regarded as valuable winter forage. However, heavy grazing has resulted in its virtual elimination from many rangeland systems.

The following strategies benefit desired plants and enhance and promote healthy rangeland systems:

- ❑ Defer grazing until seeded species are well established, usually after two growing seasons.
- ❑ Fence seeded pastures separately from native rangeland. Also fence 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.
- ❑ Avoid close grazing during fall green-up. This practice is very damaging to all grasses. 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 reserves for winter survival and early spring growth.
- ❑ Avoid heavy grazing with proper stocking rates and grass utilization levels. Heavy grazing stops grass growth and reduces vigor by affecting carbon fixation. Even aggressive-growing non-native grasses cannot tolerate close and continuous grazing. Such grazing also puts the grazed plant at a disadvantage in competing for resources with an ungrazed weed. In an eastern Washington study, the establishment of diffuse knapweed (*Centaurea diffusa*) was enhanced only when defoliation of the native bluebunch wheatgrass exceeded 60 percent. This suggests defoliation beyond this level reduced grass competitiveness.
- ❑ Rotate livestock among pastures to allow plant recovery before re-grazing. 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 2 to 3 months may be required after grazing in summer or early fall.
- ❑ Avoid grazing the same plants at the same time year after year by altering the season of pasture use. And outline the movement of livestock throughout the year across pastures.
- ❑ Prevent weed seeds from reaching the soil surface by minimizing bare ground with plant litter accumulation.
- ❑ Equalize grazing pressure among rangeland plants with multi-species grazing. Domestic sheep assist in the successional process towards a perennial grass community by usually avoiding grasses and instead, applying grazing pressure on native forbs and non-native weeds. On moderately stocked rangelands, one ewe per cow/calf pair can be added without reducing cattle production.

Regular range monitoring should be performed to evaluate the efficacy of the grazing program in maintaining the desired plant community. Range monitoring includes detecting changes in desired plant cover and noting such surface conditions as litter accumulation and exposed soil. Annual evaluations are essential to perform needed adjustments in a timely manner. Evaluate management practices at least annually, and modify when necessary.

APPENDIX A

MONTANA NOXIOUS WEEDS LIST

Noxious weeds are invasive plants that are capable of rapid spread and render land unfit or greatly limit beneficial uses. These weeds fall into three groups—Categories 1, 2 and 3.

CATEGORY 1

These weeds are currently established and generally widespread in many counties of the state. Weeds in this category are the third-highest management priority in Montana.

Canada thistle (*Cirsium arvense*)

field bindweed (*Convolvulus arvensis*)

whitetop/hoary cress (*Cardaria draba*)

leafy spurge (*Euphorbia esula*)

Russian knapweed (*Acroptilon repens*)

spotted knapweed (*Centaurea maculosa*)

Dalmatian toadflax (*Linaria dalmatica*)

St. Johnswort (*Hypericum perforatum*)

sulfur cinquefoil (*Potentilla recta*)

common tansy (*Tanacetum vulgare*)

oxeye daisy (*Chrysanthemum leucanthemum*)

houndstongue (*Cynoglossum officinale*)

diffuse knapweed (*Centaurea diffusa*)

yellow toadflax (*Linaria vulgaris*)

CATEGORY 2

These weeds have recently been introduced into the state or are rapidly spreading from current sites. They are the second-highest management priority in Montana.

dyers woad (*Isatis tinctoria*)

tansy ragwort (*Senecio jacobea*)

tamarisk or saltcedar (*Tamarix* spp.)

orange hawkweed (*Hieracium aurantiacum*)

meadow hawkweed (*Hieracium caespitosum, H. floribundum, H. piloselloides*)

perennial pepperweed (*Lepidium latifolium*)

purple loosestrife (*Lythrum salicaria, L. virgatum*)

tall buttercup (*Ranunculus acris*)

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. They are the highest management priority in Montana.

yellow starthistle (*Centaurea solstitialis*)

rush skeletonweed (*Chondrilla juncea*)

common crupina (*Crupina vulgaris*)

yellowflag iris (*Iris pseudacorus*)

Eurasian watermilfoil (*Myriophyllum spicatum*)

APPENDIX B

ROADSIDE REVEGETATION

Roadside revegetation sometimes has limited long-term success because many roadsides have low fertility and depleted biological activity. Poor nutrient cycling capacity results in inadequate retention of natural or amended nutrients. This reduces the establishment and persistence of vegetative stands.

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 enhances the chances of revegetation success and promotes establishment of persistent vegetative cover.

Roadsides act as weed pathways where repeated seed introductions from vehicle transport and frequent disturbance from roadside activities promote weed establishment. Delay of revegetation is not advised given the likelihood of rapid weed establishment. 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 compete with invasive weeds and produce extensive root systems to guard against soil erosion. Most rhizomatous species are tolerant of roadside disturbances.

Whenever practicable, select and distribute native, short-growing species, both for ecological reasons and to reduce long-term mowing maintenance. 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 roadsides occupying hundreds of thousands of acres, state and county road departments are large-scale vegetation managers. Roadsides 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, low-maintenance, self-sustaining roadside plant communities. These plant communities maintain, restore, and enhance roadside functions while reducing weed encroachment. Management tactics are site-specific and herbicides are used only when necessary.

An IRVM plan promotes the development and maintenance of functionally diverse and self-sustaining roadside plant communities. Such communities reduce 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 roadsides only when necessary.

CHEMICAL MOWING

Chemical mowing is the application of non-selective herbicides broadcast to suppress the growth of roadside vegetation. This practice is not recommended because it can permanently damage desired roadside plants. Chemical mowing was once declared far less disruptive and more economical than the mowers it replaced. Chemical mowing, however, may result in the spread of weeds by reducing desired plant competiveness.

MECHANICAL MOWING

Mechanical mowing is an important part of roadside maintenance. Proper mowing of certain roadsides is important for maintaining adequate sight distances for motorists and clear zones for use by errant vehicles. In many cases, however, mowing is performed indiscriminately or too often. This wastes public resources and can negatively affect desired vegetation, resulting in high-maintenance roadsides. Encourage the growth and vigor of desired roadside vegetation by mechanically mowing roadsides only when necessary.

To maintain adequate sight distances and clear zones, it may be necessary to mechanically mow roadsides 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 vegetative vigor and continued resource capture. When mowing during the dormant period, which for most cool-season grasses comes after mid-July, mowing to two inches is acceptable because grasses are tolerant of short mowing during dormancy.

It is not necessary to mechanically mow roadsides for aesthetic purposes when the road has a wide, developed shoulder.

APPENDIX B

ROADSIDE REVEGETATION

MOWING AND WEEDS

Besides affecting the competitive vigor of desired vegetation, improper timing of mechanical mowing can also facilitate the spread of invasive weeds. This can occur when roadsides are mowed with flail mowers after weed seeds have matured. By the same token, many roadside maintenance programs mow healthy roadside communities before desired seeds mature. This inhibits desired seed dispersal for next year's stand and the flail mowers expose the soil for weed seed, providing a competitive advantage for the weeds and cultivating even more weeds to manage in the future. Activities that give weeds an opportunity to spread should be avoided.

However, by favoring desired plant growth and decreasing the competitive vigor of weeds, properly timed mechanical mowing 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.

The most effective time to mow invasive 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 unrestricted 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) and producing reproductive structures can eventually deplete root reserves and weaken the infestation. If regrowth bolts again and produces flowers, an additional mowing will be necessary.

When the dominant vegetation is an invasive weed, mow two inches high when the weed is between the early bud and early flowering stages. However, in some cases, weeds 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 vigor, and defoliating the weeds reduces seed production and plant vigor, increasing resources available for neighboring grasses.

Carefully timed roadside mowing may reduce the density and diminish the soil seed bank of weeds through attrition. In a Montana State University study, mowing as the only management tool decreased spotted knapweed density by 85 percent when performed during the early bud stage. A further reduction in density could be anticipated with a herbicide treatment applied to the rapidly developing weed regrowth one month after mowing.

Consider mowing and applying a herbicide in a single entry with a wet-blade mower. This mower's blade cuts the plants while applying a herbicide. Cavitation pulls the herbicide into the stem and the herbicide then moves into the plant's vascular system. Because the blade precisely places the herbicide only on the stems of the cut plants, advantages of wet-blade mowing include reduced herbicide rates, runoff, and drift. Excellent results have been documented with many noxious weeds, including Canada thistle (*Cirsium arvense*), Dalmatian toadflax (*Linaria dalmatica*), leafy spurge (*Euphorbia esula*), Russian knapweed (*Acroptilon repens*), and saltcedar (*Tamarix* spp.).

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Revegetation is helpful and often necessary for speeding natural recovery and mitigating soil erosion and invasive weed establishment and growth. Revegetation is also helpful where rangeland improvement is desired.

Important steps should be considered and implemented to increase the likelihood of a successful revegetation project. Often these steps include planned events such as topsoil and vegetation salvage and replacement or the implementation of significant weed management plans to reduce weed interference on seeded species. Weed management should 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 as well as utilizing the most appropriate seeding method at the proper time. Soil amendments, seed treatments, and mulching can be used to assist seeded species establishment. Monitoring the revegetated site is necessary to quickly identify problems for timely correction. And finally, long-term management should favor the seeded species.