

After Wildfire

Section 7

Rangeland Weed Management after Wildfire

by Kim Goodwin, Project Specialist

Roger Sheley, Associate Professor

Janet Clark, Director, Center for Invasive Plant Management

Department of Land Resources & Environmental Sciences

Montana State University–Bozeman: 2002

The ecosystems of the west are adapted to a long history of wildland fires that varied in frequency and severity. Over the last 100 years or more, though, fire suppression efforts, human settlement patterns and other land use practices have changed the composition and structure of the forests and grasslands of the West. Where once we typically had periodic low-intensity fires of low severity, we now experience damaging fires that can be both intense and severe.

Wildfires can substantially affect the environment. Lack of vegetation on burned hillsides increases the likelihood of flooding and soil erosion from rain and snowfall. In turn, the water quality of streams and rivers is degraded, which affects fish populations. Wildlife populations are disrupted. However, the most environmentally and economically damaging impact of wildfires is the post-fire invasion and aggressive reestablishment of noxious weeds, which compete aggressively with

desired native species for space and nutrients. Minimizing the impact of noxious weeds requires good post-burn weed management.

Many kinds of native plants will survive and reinitiate growth soon after a fire. The ability of these plants to reestablish, thrive and reseed in subsequent years will be reduced by the presence of noxious weeds. Unfortunately, noxious weeds can thrive in recently burned areas. Fires expose ground surfaces, reduce shade and increase light, and create a flush of nutrients. All of these conditions favor weeds. Wildlife habitat, livestock grazing, watershed stability and water quality may be compromised. Large-scale infestations of noxious weeds are difficult, and costly, to manage.

Under some circumstances, revegetation is a solution. Because revegetation can work to provide competition, it is often the first step in preventing or suppressing noxious weeds.

Revegetation isn't always indicated, however. It should be constrained by the abundance of available plants and propagules (their seeds, root crowns and rhizomes) at the site that direct natural recovery. To avoid suppressing the native plant community, burned areas with adequate desired plants and propagules should not be revegetated. Good weed management practices (prevention, detection and eradication) will be necessary in burned areas. Established populations will require long-term management that includes mechanical, chemical, cultural and sometimes biological control efforts.

The purpose of this publication is to describe practical and proven weed management methods that may be incorporated into a successful burned-area noxious weed management plan. Such a plan helps the land manager prevent weed establishment, mitigate the reestablishment of noxious weeds in burned areas and establish or maintain healthy plant communities.

1 – Evaluating the potential for natural recovery

Before formulating a burned-area weed management plan, determine the degree of burn severity and estimate the degree of noxious weed cover on the area before it burned. These facts will allow you to assess the potential for natural recovery of the plant community and thus decide whether to revegetate or to allow natural regeneration.

Burn severity and the survival of desired plants

Burn intensity is a function of fire temperature and duration, which are largely determined by wind speed and the amount of fuel present. Burn severity is a function of the amount of moisture in the organic soil layer during a fire. A high-intensity, low-severity burn can occur when fuels

are dry but the litter/duff layer is wet. Although such a fire burns intensely, the wet organic layer will protect the subsurface from much of the heat, so the fire will likely not be severe.

Plant survival is largely determined by burn severity. Low-severity fires favor plant survival over high-severity fires (see Table 1). However, survival can also be influenced by a plant's reproductive and structural characteristics.

AFTER WILDFIRE

Noxious weed cover and survival

After assessing the severity of the burn, estimate noxious weed cover before the fire. (See Appendix A, Montana County Noxious Weed List.) Unless you recorded the degree of weed cover before the fire, it may not be easy to estimate the extent of pre-burn noxious weed cover. But if areas immediately adjacent to the burned area have moderate noxious weed cover, it is possible that the burned area had the same degree of cover by the same weeds. If so, and depending upon the severity of the burn and weed characteristics, you can expect some degree of noxious weed survival.

Many noxious weeds can reproduce vegetatively from rhizomes, which bear vegetative root buds capable of producing new, independent plants (See Appendix B, Rhizome-spreading Noxious Weeds of Montana). These weeds have extensive root systems that can grow quite deep. The roots of leafy spurge (*Euphorbia esula*) can extend to depths of 26 feet, with vegetative root buds at depths of 10 feet or more. The roots of Canada thistle (*Cirsium arvense*) can penetrate the soil as deep as 22 feet. Because even the most severe fires typically damage roots only to four inches below the soil, these noxious weeds have an excellent chance of surviving and aggressively reestablishing, even after very severe fires.

Fires expose ground surfaces, cause a flush of nutrients and create conditions of high light and low

NOTE—> Weed survival after fire should be expected, and reestablishment mitigated through integrated weed management techniques. Many noxious weeds have below-ground crowns; some can also reproduce vegetatively from roots or rhizomes. Such weeds are protected from the damaging effects of fire. They will survive fire and quickly resprout and respread, taking early advantage of the disturbances created by fire. Weeds may also endure a fire through buried seeds.

Table 1. Determining Burn Severity

Adapted from "Fire Burn Severity," Gallatin National Forest [unpublished]

<i>Burned area characteristics—</i>	Low severity	Medium severity	High severity
<i>Soil color and condition</i>	Up to 2" of soil darkened brown to reddish-brown below the duff or ash layer; soil is not physically affected	Normal color; soil is not physically affected	2" to 4" of soil is darkened reddish orange; soil can be physically affected; crusted, crystallized, and/or agglomerated
<i>Duff and debris</i>	Duff and debris partly burned	Duff consumed; burned debris (e.g. needles) still evident	Duff and debris entirely consumed
<i>Ash characteristics</i>	Generally dark-colored	Dark-colored ash present	Uniformly gray/white ash present; in severe cases, ash is white and light
<i>Hydrophobicity</i> ¹	Low to absent; water infiltration not significantly changed	Low to medium on surface soil and up to 1" deep	Medium to high, up to 2" deep
<i>Shrub, stump, small fuels condition</i>	Slightly charred	Charred but still present	Entirely absent
<i>Plant survival</i> ²	High; crowns and surface roots will resprout quickly	Moderate; roots and rhizomes below 1" will resprout	Roots burned up to 4" below surface; roots and rhizomes deep in soil can resprout
<i>Recovery potential</i> ³	Quick; natural recovery within one to two years	Modest; natural recovery in two to five years	Slow; natural recovery limited

1. Hydrophobicity is the ability of water to infiltrate the soil after intense heating. To determine hydrophobicity, scrape ash away and pour water on the soil surface. Soil is hydrophobic if the water beads at the soil surface. Test for hydrophobicity at several depths (up to four inches), for hot fires can drive hydrophobic layers several inches into the soil.
2. To measure plant survival, examine root damage by digging into the soil and evaluating the extent of root burning, evidenced by roots that are hard and nonpliable. Plant survival is also a factor of seed viability in the soil.
3. Delayed recovery time likely with moderate to high noxious weed cover.

shade. All of these effects can result in the rapid growth and expansion of weeds in burned areas. For example, on a forested site in Montana, spotted knapweed (*Centaurea maculosa*) increased almost sixfold within two years of a controlled burn.

Fortunately, weed reestablishment can be mitigated with an effective burned-area weed management plan. An initial component of such a plan may be revegetation.

When indicated, revegetation can suppress noxious weeds by introducing competing plants. To determine whether revegetation is needed, begin by measuring the overall burn severity of the site (see Table 1) and estimating the extent of pre-burn noxious weed cover. Once these are known you can begin to assess the need for revegetation (see Table 2). Typically revegetation should be constrained by the abundance of available plants and propagators—again, the plants themselves, and seeds, root crowns and rhizomes—that direct natural recovery.

As a rule, the more severe the burn and the greater the degree of pre-burn noxious weed cover, the more likely the need for revegetation (see Fig. 1). If you decide that revegetation is not needed and opt to allow for natural regeneration, plan to monitor the area frequently for new weeds until the plant community has recovered. Afterwards, monitor for weeds occasionally.

It is a good idea to determine soon after the fire whether revegetation is needed. Considering the severity of the burn, the degree of pre-burn weed cover, and the anticipated desired vegetation cover can help you plan a fall-dormant seeding. (Fall is usually the most effective time to seed.) If you postpone deciding whether to revegetate, keep an eye on the degree of weed cover and of desired vegetation cover.

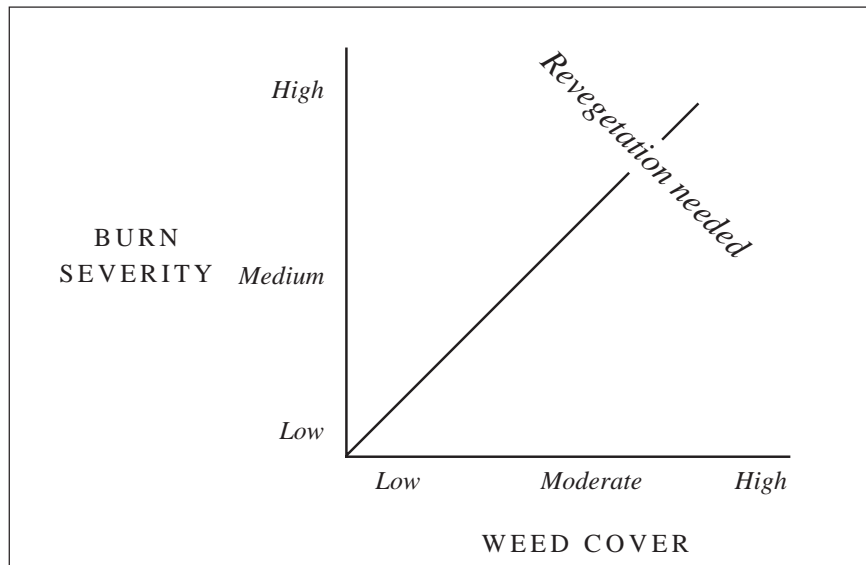


Figure 1

2. Revegetating, Establishing and Managing Competitive Plants

To help prevent weed establishment, revegetating with competitive plants is recommended when the desired vegetation canopy is inadequate (under 20–30 percent, depending on site conditions; see Table 2). That is, revegetation should ordinarily not be considered in areas where the desired vegetation cover is more than 30 percent. Revegetating such areas is typically unnecessary, and in fact can suppress the native plant community.

When revegetation is necessary

As noted, revegetation as a weed management strategy is recommended in areas that experienced a high-severity burn. It is also indicated when the site bears inadequate desired vegetation cover regardless of burn severity (Table 2). These areas typically will have low natural recovery potentials—they don't recover well on their own. Other considerations are slope and proximity to drainages (see note at right).

Burned areas requiring revegetation for weed management purposes may present the following conditions:

- Moderate to high quantities of survived weeds as viable seeds, crowns or rhizomes
- Habitat of high nutrient levels,

exposed ground surfaces and low shade/high light conditions, and

- Inadequate desired vegetation cover owing to fire severity or pre-burn displacement by noxious weeds or both.

NOTE→ Every effort should be made to determine whether revegetation is necessary (Table 2) as soon as possible after the fire. If it is, a fall-dormant seeding into the ash layer immediately following the fire is a good idea.

Formulating a seed mix

If you decide to revegetate, you'll need to design a suitable seed mix. Typically you'll want an aggressive, quick-establishing mix of grasses and forbs that can effectively occupy all available niches. (Do not include forbs if you plan broadcast treatments with broadleaf herbicides.) The seed mixture should be certified weed-free.

Formulating an appropriate seed mix is typically based on the area's intended use, how soon (and how well) the desired plants are likely to establish, competitiveness, soil attributes, precipitation, temperature

AFTER WILDFIRE

and elevation. Local Extension agents, county weed district coordinators and Natural Resource Conservation Service field offices are good sources of information on the environmental and establishment requirements of seeded species, including species compatibility and avoidance of niche overlap. They can assist in formulating a seed mix. (See Appendix D, pp. 45–48.)

Here are some things to consider:

Intended use of the area: If livestock grazing is the intended use, an aggressive perennial grass that provides high forage production and nutritional value could be the dominant species of a simple mix. If the burned area will not be used for grazing (e.g., natural areas), aggressive-growing native species that can provide ecologic stability and effectively compete with noxious weeds will help maintain the integrity of the plant community. The addition of nitrogen-fixing legumes such as lupine (*Lupinus* spp.) can improve the soil structure and enhance the establishment of native-seeded species.

Competitiveness: Include a diversity of aggressive, quick-establishing species that can effectively occupy the niches the fire opened up, use available resources, and thus compete with noxious weeds.

Establishment: Species differ in how quickly and how well they establish. Some non-native wheatgrasses are the easiest to establish. Generally, natives are slower and more difficult to establish, but once established they often require less labor and expense to maintain.

Soils: Soil texture can guide your seed choices. Most seeded species prefer medium- to fine-textured soils. However, Indian ricegrass (*Achnatherum hymenoides*) and

“Niche” is a habitat that contains attributes necessary for a plant or animal to live. An available niche for a plant could be bare ground with suitable resources, such as those produced by fire.

Table 2. Determining the necessity of burned-area vegetation

<i>Degree of noxious weed cover</i>	Burn severity—		
	Low	Medium	High
Absent to low—up to 20% weed cover (i.e., rare to regularly scattered weed occurrence) <i>High pre-burn cover of desired vegetation</i>	Revegetation not necessary; ecological effects generally beneficial; regularly monitor for new weeds until community reaches recovery, then monitor occasionally	Revegetation not necessary; ecological effects generally beneficial; regularly monitor for new weeds until community reaches recovery, then monitor occasionally	Revegetation and regular weed management recommended
Moderate—20 to 80% weed cover (i.e., frequent to fairly dense weed occurrence) <i>Moderate pre-burn cover of desired vegetation</i>	Revegetation may be necessary if desired vegetation cover is below 30%; frequent weed management recommended; high survival of most weed species	Revegetation may be necessary if desired vegetation cover is below 30%; frequent weed management recommended; high survival of most weed species	Revegetation and frequent weed management recommended; weed survival varies among species*
High—80 to 90% weed cover (i.e., dense weed occurrence to monoculture) <i>Low to absent pre-burn cover of desired vegetation</i>	Revegetation and intense weed management recommended; high survival of most weed species*	Revegetation and intense weed management recommended; weed survival varies among species*	Revegetation and intense weed management recommended; weed survival varies among species*

* Rhizomatous weeds have high survival as underground reproductive structures capable of reproduction. Weed survival as crowns or viable seeds varies among species.

pubescent wheatgrass (*Elytrigia intermedia* spp. *trichophorum*) are well adapted to sandy soils, and western wheatgrass (*Pascopyrum smithii*) does well in clay soils. The optimal soil texture—i.e., loam—comprises 45 percent sand, 35 percent silt, and 20 percent clay.

Testing soil chemistry can help determine species selection and soil amendments. Soil may be tested for pH (the optimal range is 6.5 to 7.5; ash may temporarily affect the soil pH), electrical conductivity (optimal range is 0–8 mmhos/cm soluble salts), sodium adsorption ratio (optimum is <6), and organic matter (optimum is >3%).

Precipitation, temperature and elevation: Seeded species need to be adapted to the precipitation level,

temperature zone and elevation of the site. Locally adapted plants can have excellent establishment.

Seedbeds and seeding methods

If they’re seeded right after the fire, most burned areas require no seedbed preparation. Ash from the fire helps cover and retain broadcasted seeds. The wet/dry, freeze/thaw action of moisture will work the seeds into the soil while also breaking down any hydrophobic soil layers. Frost heaving will break down ash crusts that form because of fall rains before or after reseeding.

A missed opportunity to reseed immediately following the fire may direct the nature of reseeding the following fall, when the protective effects of the ash layer are no longer

available. It is likely that the burned area will need seedbed preparation before you broadcast seeds. This preparation, which makes soil receptive to the seeds, enhances seed germination and seedling establishment.

Where practicable, seedbeds can be prepared by dragging small chains or raking the soil surface both before and after seed broadcast. (If the site is steep or extremely rocky or remote and inaccessible, it may be impossible to prepare seedbeds. Counter these difficulties by doubling or trebling the broadcast rate recommended for drill seeding.)

A site accessible to equipment can be seeded with a no-till drill. This tractor-pulled machine opens a furrow in the soil, drops seeds in the furrow at a specified rate and depth, and rolls the furrow closed. By placing seeds at the proper depth, this method of seeding enhances seedling establishment while minimizing the disturbance of soil and of existing plants. Ideal seeding depths are about one-quarter inch for small seeds, about one-half inch for large.

Enhancing the establishment of seeded species

Good germination and establishment can initiate successful revegetation. Hallmarks of a good revegetation plan typically include:

- using species adapted to conditions of the site;
- if an ash layer is absent, preparing a seedbed before and after broadcast seeding. Use a no-till drill if

the site is accessible to equipment.

- adding nitrogen-fixing legumes to improve the soil structure and contribute to a healthy nitrogen cycle, which is essential to long-term revegetation success;
- increasing seeding rates to:
 - improve the chances of desired seeds' competing successfully with weeds, and
 - increase the likelihood that adequate amounts of broadcast seeds find safe sites;
- providing a protective mulch cover, such as native certified weed-free hay, to protect soil and seeds from erosion, to conserve soil moisture and to moderate soil temperatures. Native hay mulch can contain seeds of native plants, which help diversify the plant community.
- removing as many noxious weeds as possible (usually with herbicide applications); and
- deferring grazing by means of fencing or herding until vegetation has been successfully established, usually after two growing seasons. When palatable, slow-maturing shrubs are recovering, do not graze until they have produced viable seeds.

Managing competitive plants

If you intend to graze a recovered burned area, adopt grazing practices that encourage desired plant growth that will limit weed resources—light, water, nutrients. Your grazing plan should promote the growth and vigor

of the desired plant community and minimize the establishment and spread of noxious weeds. Devising and implementing a grazing program to favor the desired species is important to avoid wasting money and effort spent on revegetation.

Devising a grazing program

Multispecies grazing, where domestic sheep are incorporated with cattle grazing systems, can be integrated into a management program to distribute grazing pressures more uniformly across pastures and among plants, including noxious weeds. When integrated properly, multispecies grazing can direct a rangeland system toward a highly productive perennial grass climax community.

A grazing management program also includes methods that encourage competitive plant growth, directly enhancing and promoting a healthy rangeland system. Among such methods are:

- Defer grazing in burned areas until seedlings are well established
- Avoid heavy grazing by determining and implementing proper stocking rates
- Alter the season of use: Avoid grazing the same plants at the same time year after year
- Rotate livestock between pastures to allow plant recovery before being regrazed
- Outline the movement of livestock throughout the year, and
- Minimize bare ground by promoting the accumulation of plant litter.
- Monitor your rangeland to see whether the grazing program is encouraging competitive plant growth and limiting weed invasion, establishment and growth. A good range monitoring program keeps track of grazing patterns, detects changes in the mix of weeds and desired plants, and ascertains such soil surface conditions as litter accumulation and exposed soil. An annual evaluation allows for timely adjustments to the grazing program.

SLOPE & DRAINAGE CONSIDERATIONS

Slope: Soil erosion can occur from runoff due to lack of vegetation. Moderate burn severity slopes above 15 percent usually require quick protection with annual ryegrass (*Lolium multiflorum*) or small grains. Stabilize surface movement with hay mulch held by netting or an organic tackifier. Slopes benefit from cross-slope log erosion barriers or contour scarification when hydrophobic soils occur. Slash filter windrows at toeslopes are beneficial at further stabilizing soils.

Proximity to drainages: Revegetate channels to mitigate serious erosion during increased flows and to filter sedimentation from runoff; riparian buffer plantings along stream corridors are common. For quick temporary cover and protection, annual ryegrass at 10 pounds per acre, or small grains at 20 pounds per acre, is frequently seeded within 50 feet of drainage channels, regardless of burn severity. Taken in part from Wiersum, Fidel and Comfort (2000); see Appendix D

3 – Integrated Weed Management

Integrated weed management (IWM) is a multidisciplinary approach to preventing and managing weeds. An IWM plan incorporates a combination of preventive strategies and management techniques that promote a healthy plant community.

Burned areas and adjacent lands are best managed under burned-area IWM plans. Central to such plans are prevention and early detection and eradication strategies that hinder the spread of weeds into weed-free areas.

Small or newly established patches are responsive to eradication programs. Large infestations require an integrated management program that works toward developing a healthy plant community. If desired plant competition is lacking—a feature of large infestations—then IWM may call for mechanical, chemical, cultural, and in some cases biological control measures to be followed by revegetation.

Land-management goals set conditions for the management area to be developed or preserved. One might be “to increase the productive capacity of the land for livestock production” or “to develop healthy plant communities to enhance rangeland and wildlife habitat.” Measurable weed management objectives provide a link between goal statements and weed-management actions. Examples might include, “prevent weed establishment in weed-free areas over the next three years,” and “eradicate small patches by preventing reproduction over the next three years.”

To determine whether an IWM plan is working as it should, the land manager might monitor and regularly evaluate conditions of the area. Are the predetermined land-management goals and weed-management objectives being met? The answer will come from making observations, gathering data and keeping records of site conditions

and trends. By comparing this with data from earlier years, an IWM plan can be adjusted as needed.

Prevention & early detection

Preventing noxious weeds from establishing in the first place is the most effective and least costly method of weed management. It is important to identify high-quality and valued areas—areas with high desired plant cover, areas that are relatively free of weeds—and protect them from weed establishment. Preventing establishment can be accomplished by:

- Limiting weed seed dispersal
- Detecting and eradicating weeds early
- Revegetating when necessary, and
- Properly managing desired plants to prevent invasion.

Limiting the dispersal of weed seeds

Preventing or greatly limiting seed dispersal is an important component in minimizing the introduction or spread of weeds. Seed dispersal can be reduced by:

- Using only certified noxious weed-free gravel, seed mixes, forage and mulch
- Thoroughly cleaning the undercarriage and tires of vehicles and heavy equipment before entering a burned area. Except when necessary, vehicle travel in such areas should be limited to established roads. This will limit seed dispersal from vehicles and avoid compacting soil that could hinder the establishment or recovery of desired plants.
- Avoiding adjacent weed-infested areas during the seeding period. Weed seeds can be transported on boots, clothing and animals.
- During the seeding period, avoid moving livestock into weed-free areas from infested areas. If livestock must be moved into a

weed-free area from an infested area during this period, the animals should be held in a drylot for at least five days to allow any viable weed seeds to pass.

- Detecting weeds early and eradicating before seeds develop and disperse. Hand-pull or dig up entire plants. Clip, bag and burn seed heads.
- Eradicating small patches and controlling or containing large infestations.

Detecting & eradicating weed introductions early on

Early detection of new weeds through monitoring is crucial in preventing their establishment. Incorporating a systematic monitoring program within a burned-area IWM plan permits the early identification and eradication of new weeds and small patches.

Formulating a monitoring plan

Surveying and eradicating new weeds through a methodical, organized monitoring plan is essential to prevent weed establishment. A key component to sustainable and effective weed management is minimizing weed establishment throughout the management area with special attention paid to eradicating weeds in and protecting high-quality areas—that is, areas with high desired plant cover—and valued areas.

A monitoring plan for small burned areas or smaller units within large burned areas might include the following schedule, with efforts concentrated along fire lines, roadways, railways, and waterways, where weed infestations often begin, and in protected areas:

- Spring and early summer: Methodically examine the area when young weeds can be hand-pulled¹ or dug up or treated with an appropriate herbicide.
- Summer: Examine the area again during the early bud stage to eradicate any previously overlooked weeds. Preventing seed dispersal is critical; applying

The goal of IWM is to develop and maintain healthy, desired plant communities.

MONITORING AND EVALUATION

Monitoring plans that detect weeds early for quick eradication are a critical component of IWM. They are also helpful in evaluating the effectiveness of grazing management plans and weed management plans.

Monitoring and evaluation can identify changes in site conditions (such as exposed soil) and vegetation trends (such as weed and desired plant cover.) This information can be recorded and annually evaluated to allow for timely plan modifications.

The following monitoring components should be included to properly evaluate the effectiveness of a weed management plan:

Annually examine areas that are determined to be particularly susceptible to weed infestations; assess efforts in limiting weed invasion, establishment and growth; measure the size and density of weed infestations; and record information on past and current weed management.

herbicides after the late flowering stage generally won't prevent seed production.

- Early fall: Examine the area again to:
 - ___ Remove entire plants (by hand-pulling or digging)
 - ___ Clip, bag and burn seed heads, and
 - ___ Treat any regrowth with an appropriate herbicide.

If the burned area is large, it should be divided into smaller and more manageable areas and methodically examined for weeds. Such smaller areas might be based on administrative boundaries, vegetation or soil types. Sites to be surveyed could be determined by randomly selecting a number of grid sections within each smaller unit. Transect lines within each grid section could then be established to cross the landscape and uniformly sample for weeds. Sampling transect lines for weed occurrences can be very time-consuming; using permanent transect lines is often limited to aiding visual monitoring of the effectiveness of management strategies in large infestations.

Eradicating small weed patches

Eradicating small patches can assist in preventing or greatly limiting seed dispersal and preclude the development of large infestations. Eradication is most effective on newly established weed populations or those smaller than

100 square feet. Individual weeds must be removed and steadily replaced with desired plants (through natural replacement or revegetation) until all viable seeds have been depleted from the soil. If eradication is to succeed, weed reproduction must be stopped completely. Therefore issues of seed dormancy and longevity in the soil must be considered in long-term management for eradication.

An IWM plan should incorporate an eradication program for small patches. Components of such a program might include:

- Prioritizing your management efforts. Low-density patches respond more quickly than high-density patches to eradication.
- Monitoring the area you're managing for weeds. Document changes in patch size and density at least once a year; and
- Flagging patches, or identifying them using Global Positioning System (GPS), to make them easy to find again in the spring, during the vulnerable seedling/rosette stage.

Manage with frequent follow-up to:

- ___ Remove weeds by hand-pulling or digging or with herbicides
- ___ Clip, bag, and burn seed heads, and
- ___ Revegetate if the desired vegetation cover within the patch is inadequate.

Managing large infestations

Large infestations require an IWM plan. Such a plan should prevent or greatly limit seed dispersal while moving toward the reestablishment of a healthy plant community. Successfully dealing with large infestations requires the use of many management methods. Relying on a single method frequently results in failure.

When combined appropriately, four main methods are effective in managing large infestations: mechanical, chemical, cultural, and biological.

Mechanical Control

Where equipment can be brought onto the site, mowing can be an effective method for managing some large-scale noxious weed infestations, especially when mowing is integrated with cultural or chemical treatments. The effectiveness of mowing is based on timing during the growing season and the biological characteristics of the target weed.

Properly timed mowing reduces weed competition and limits seed dispersal while encouraging desired plant growth and vigor. The best time to mow a perennial weed infestation is during the flowering stage. Mowing short (to two inches in height) and mowing any regrowth after it reaches this stage can weaken the infestation over time by depleting root reserves. This timing is especially important when mowing rhizomatous weeds, since their root systems have large energy-storage capacities. Frequent mowings may be necessary, but only after any regrowth has reached the flowering stage.

Infestations with a moderate to high cover of desired vegetation should be mowed short when the weeds have reached the flowering stage and the grasses are dormant.

Depending on the type of dominant grass, some weeds will bolt and extend above the height of these grasses. If the desired vegetation has not dispersed its seeds or is not yet dormant, mowers can be set to cut just above the grass seed heads. This defoliates a percentage of the weeds,

¹ Rhizomatous weeds have the ability to spread through underground stems. Regular and repeated hand-pulling can be effective if the entire root crown is removed. However, hand-pulling rhizomatous weeds can cause adventitious growth and increased stem densities until root reserves are depleted.

LARGE INFESTATIONS

No method or combination of methods can achieve eradication for large weed infestations. However, containment (managing infestation perimeters) or control (managing entire populations) are effective in preventing or greatly limiting seed dispersal into adjacent areas.

Large infestations should be managed toward reestablishing healthy plant communities. This process begins with shifting the competitive balance from the infestation to the desired plants through revegetation after the infestation has been successfully weakened by:

- Mechanical controls, such as mowing
 - Chemical controls, such as herbicide treatments
 - Cultural controls, such as grazing and encouraging the growth of desired vegetation; and
 - Biological controls, such as weed-damaging insects.
-

reducing their vigor and seed production while increasing the availability of resources to desired neighboring plants. Unrestricted grass growth also allows seed dispersal for next year's stand and maintains the strong competitive vigor needed to minimize weed re-invasion.

Mowing can increase weed density through increased germination from seeds in the soil or by stimulating shoot production from root buds in rhizomatous weeds. Mowing annually at roughly monthly intervals during the flowering stage can effectively weaken an infestation over time by affecting underground reserves. Revegetating (if necessary) and combining mowing with an appropriate herbicide applied one month after the last mowing can enhance management.

NOTE→ Long-term repeated mowing can cause prostrate growth. Periodic herbicide treatments can remove weeds that have acclimated to frequent mowing.

Chemical Control

Herbicides eradicate weeds or greatly reduce weed vigor. Herbicides can reduce photosynthesis, disrupt vegetative growth, or interrupt the production of essential proteins. Treating weeds increases the availability of resources needed by desired neighboring plants.

Herbicides are particularly effective in providing long-term control of an infestation when a healthy plant community is present. When a healthy plant community is not present, the target weed or another weed species can become established after the residual effects of the herbicide have dissipated. Revegetate if necessary to attain long-term control of an infestation.

Selecting the right herbicide

The selection of an appropriate herbicide depends upon:

- The target weed
- Weed density
- Herbicide toxicity
- Herbicide degradation time
- Desired vegetation cover
- Soil attributes
- Proximity to water, and
- Environmental conditions.

Land managers should familiarize themselves with each of these factors to select the most appropriate herbicide. Extension specialists or county weed coordinators are good sources for herbicide recommendations. Local commercial herbicide applicators are available to help with choosing and applying herbicides, and are particularly good resources when restricted-use herbicides are advised.

Timing the application of herbicides

The most effective times to apply nonresidual systemic herbicides are during the seedling/rosette, early bud, and fall regrowth stages—perennial weeds' most vulnerable periods. Treatments during these periods can ensure the translocation of the herbicide to roots or rhizomes.

Application timing of soil-residual herbicides is less important than herbicides with no residual activity because weeds that emerge and begin to grow within the treated soil zone continue to be exposed to the herbicide through their roots. The best application times for soil-residual herbicides are spring and fall.

RHIZOMATOUS WEEDS & FIRE

Noxious weeds will increase growth as a result of survival coupled with fire-produced disturbances. Growth of rhizomatous weeds is especially enhanced through the survival of underground reproductive structures that have access to large energy reserves. When above-ground weed growth is removed, such as by fire, vegetative shoot production is strongly stimulated, directly producing great numbers of individual weeds. Because of the established root reserves, these shoots are immediately aggressive and highly competitive.

ELEMENTS OF SUCCESSFUL LONG-TERM REVEGETATION

Successful revegetation of large infestations includes the following:

- Determining whether revegetation is necessary based on weed and desired plant cover (see Table , p. n). Consider revegetation when the desired vegetation cover is inadequate.
 - Formulating a site-adapted seed mix and preparing a seedbed or drill-seeding.
 - Enhancing seedling establishment by removing weeds, increasing seeding rates and excluding livestock, and
 - Properly managing established vegetation.
-

Suggested placement of herbicides

The size of an infestation determines how herbicides can best be used. An infestation moderate in size might receive infestation-wide treatment. If necessary, revegetation could follow as a fall-dormant reseed. By contrast, an infestation very large in size—too large for infestation-wide control—might receive perimeter treatment, a containment approach designed to concentrate efforts on the advancing edge of the infestation. Because containment programs are designed to limit infestation spread, such programs typically require a long-term commitment to herbicide treatments. Containing infestations that are too large to eradicate is cost-effective because it protects adjacent uninfested areas and thereby enhances the chances for success of large-scale management programs.

NOTE→ Since many herbicides are subject to photodegradation or volatilization, don't apply them during the heat of the summer.

Cultural Control

Cultural control methods promote the growth and competitiveness of desired plants by establishing or properly managing a healthy plant community. This can provide resource competition with weeds and provide relative weed-resistance to future invaders. Cultural control methods include revegetation, proper management of desired plants (see “*Managing competitive plants*,” p. 33) and grazing.

Revegetation is an essential IWM plan component when the desired

vegetation cover is inadequate to fill available niches within an infestation. As management efforts eradicate individual weeds from an infestation, the desired plants typically cannot fill every open niche. As a result, the target weed (or another weed species) fills these niches and the infestation isn't improved despite costly and time-consuming management.

Successful infestation management steadily replaces vacant weed sites with desired vegetation. Such replacements can eventually shift the competitive balance from the infestation to the desired plants. Effective niche occupation and the eventual reestablishment of a healthy plant community made up of an array of aggressive, quick-establishing species can minimize re-invasion.

“Single-entry” revegetation

Traditionally, successful revegetation of areas heavily infested by weeds has been an expensive multi-attempt, multi-entry approach. Establishing a desired plant community typically entailed making many entries into the affected field, and required a number of attempts before success was achieved.

By contrast, a “single-entry” approach is cost-effective and yields reliable revegetation. With one late-fall field entry, a residual broadleaf herbicide can be applied at the same time as grasses are seeded with a no-till drill. In one study, researchers combined eight herbicide treatments and three grass species at two Montana sites infested with spotted knapweed. The best revegetation success resulted from the application of picloram at one-half or one pint per acre with “Luna” pubescent wheat-

grass as the seeded species. This cost-effective and reliable single-entry revegetation strategy could be a major component of many sustainable weed management programs.

Cultural control through grazing

Domestic sheep prefer to graze broad-leaved plants (forbs—including noxious weeds) over grasses. Sheep grazing has been shown to be an effective and useful method of managing large infestations while assisting the successional process toward a perennial grass climax community.

The optimal time to graze domestic sheep is during the early bud stage of the weed, the stage that's most susceptible to defoliation. Repeated grazing during this period can weaken the weeds and, over time, reduce the ability of the weeds to compete with desired plants.

It takes a long-term commitment to effectively manage large infestations by reducing weed densities through grazing. During the first few years, sheep grazing can actually increase infestation stem densities by stimulating shoot growth in rhizomatous weeds such as leafy spurge. Over time, however, continuous grazing of an infestation will begin affecting underground reserves; eventually it will reduce stem densities. For instance, in Saskatchewan, summer-long continuous sheep grazing had no effect on leafy spurge stem densities for the first three years, after which densities declined dramatically.

Integrating grazing with other control methods can be effective in managing large infestations. For instance, grazing leafy spurge with sheep during spring and summer can remove excess canopy and stimulate shoots to grow in the fall. A fall application of an appropriate

NOTE→ Grazing an infestation during the early bud stage can prevent seed development and dispersal. Grazing pressure is usually directed toward the new growth, which is high in crude protein and highly digestible.

herbicide then acts on the rapidly developing regrowth.

Integrating grazing with insect biocontrols can be effective. One researcher found that in small-scale field trials over three years, sheep grazing and the flea beetle (*Aphthona nigriscutis*) together reduced densities of leafy spurge more than sheep-grazing or the flea beetles did alone.

Biological Control

The noxious weeds of Montana (see Appendix A, p. 42) are native to Eurasia. These plants arrived in North America without their coexisting natural enemies—diseases, parasites, predators, etc. In their native countries, natural enemies help keep the plant populations at stable densities. Upon these plants' arrival in North America, the absence of natural enemies predisposed aggressive invasion and growth characteristics.

Biological control methods reunite a target weed with its host-specific natural enemies (see Table 3.) Management by biological control has been effective on some large-scale weed infestations. However, biological control will not eliminate or prevent the spread of the target weed; it aims instead at reducing the density of the target weed to a stable, non-damaging level.

Insect biocontrols remove valuable fluids, defoliate, eat seeds, and bore into the roots, shoots and stems of target weeds. These feeding actions can greatly reduce the competitive abilities of the infestation by weakening and removing individual weeds within the infestation. At this stage in management, revegetation can be highly successful.

Biological control can be especially effective when integrated with other management techniques such as sheep-grazing, revegetation or herbicide treatments. If choosing integration with herbicides, separation between the insect biocontrol and the herbicide may need to be addressed to avoid damaging the biocontrol population. For instance, agents could be distributed in the middle of the infestation while treating the perimeter with herbicides.

Table 3. Selected biological control agents

Weed	Agent	Type of agent	Mode of action
Canada thistle	<i>Ceutorhynchus litura</i>	beetle	Stem-borer
Dalmatian toadflax	<i>Calophasia lunula</i>	moth	Foliage feeder
leafy spurge	<i>Oberea erythrocephala</i>	beetle	Stem & root feeder
leafy spurge	<i>Aphthona lacertosa</i>	beetle	Root feeder
leafy spurge	<i>A. nigriscutis</i>	beetle	Root feeder
purple loosestrife	<i>Galerucella californiensis</i>	beetle	Foliage feeder
purple loosestrife	<i>G. pusilla</i>	beetle	Foliage feeder
spotted knapweed	<i>Larinus minutus</i>	beetle	Flowerhead feeder
spotted knapweed	<i>Cyphocleonus achates</i>	beetle	Root feeder
spotted knapweed	<i>Urophora affinis</i>	fly	Flowerhead feeder
spotted knapweed	<i>U. quadrifasciata</i>	fly	Flowerhead feeder
spotted knapweed	<i>Agapeta zoegana</i>	moth	Root feeder
St. Johnswort	<i>Chrysolina quadrigemini</i>	beetle	Foliage feeder
tansy ragwort	<i>Pegohylemyia seneciella</i>	fly	Flowerhead feeder
tansy ragwort	<i>Tyria jacobaeae</i>	moth	Foliage feeder

Contact your local county Extension agent or county weed coordinator for information on how to obtain biological control agents.

Monitoring & evaluation

Monitoring is the repeated collection and analysis of information to evaluate progress in meeting management goals and objectives. Periodic observation is necessary to evaluate the effectiveness of the weed management plan. If management objectives are not being met, weed control actions need to be modified. Without monitoring there is no way to determine whether control actions are contributing to the fulfillment of management objectives.

A monitoring plan is needed in eradicating small patches or reducing infestations. Monitoring can confirm that the size of the infestation and its density is declining year by year.

A monitoring plan need not be elaborate. For example, a land manager can establish photo-points to detect vegetation changes over time—a suitable alternative, in some cases, to the more detailed monitoring and evaluation strategies that make use of simple transects.

County Extension and NRCS field offices can provide assistance in the use of transects to monitor changes in vegetation. One effective strategy is

to annually measure the size of an infestation and to measure the average weed density using the following simple transect procedure:

1. Build a simple rectangular plot frame 2 feet x 4.5 feet using 1/2-inch PVC pipe with four elbow joints. This plot frame will cover one square yard of ground.
2. Visit the weed patch and run a measuring tape the length of the patch. Choose 15 random points along that length.
3. Place the plot frame along each point and count the number of individual weeds or stems (if rhizomatous) within the frame.
4. Calculate the average weed density by adding the numbers and dividing by 15.

The value of the data collected grows year by year, permitting the manager to spot trends in the infestation. Monitor protected areas frequently to ensure that weed establishment is prevented. Every year, measure small patches you're managing for eradication and moderate-size infestations you're managing for reduction of size and density and development toward a healthy plant community. If monitoring demonstrates that the desired reduction in size and density is not being achieved, modify your weed management plan.

4 – Developing a burned-area IWM plan

Noxious weeds are likely to become established in many burned areas because fire-produced disturbances favor weed colonization. Rapid weed reestablishment and exponential growth is likely when weed survival is coupled with disturbances such as the flush of nutrients, exposed ground surfaces, and low shade with high light conditions. An effective burned-area IWM plan can help prevent weed invasion and further the reestablishment of desired plants.

An IWM plan for a burned area requires more steps, and more coordination, than a standard IWM plan. For

instance, when weed management occurs immediately following the fire (typically during the fall months), burn severity and pre-burn weed and desired plant cover should be determined or estimated. This information helps the manager decide whether to revegetate. If revegetation is determined to be necessary, a fall-dormant broadcast reseeding effort during the fall or winter following the fire is a good idea.

When the need for revegetation wasn't determined immediately following the fire, the manager should base a burned-area IWM plan on the assumption that noxious weeds were

present, and may also assume rapid and expanded weed growth. The plan would be implemented in the spring, and would be followed by a fall-dormant seeding if the desired plant cover is inadequate. Monitoring and annually evaluating the site allows the manager to determine the adequacy of the plan and to adapt it as needed.

Appendix C (p. 44) is a schematic or flowchart of a decision-making process that can help a manager prepare a burned-area IWM plan.

Summary

Fire-produced disturbances directly favor colonization of new and survived noxious weeds. To prevent or mitigate establishment of noxious weeds, and to establish or maintain healthy plant communities, burned and adjacent areas should be managed under a burned-area IWM plan.

When desired plant cover is inadequate, the first step of many burned-area IWM plans is revegetation. Revegetation, when needed, can mitigate weed invasion and reestablishment by introducing desired plants that compete with weeds for resources.

A burned-area IWM plan incorporates land management goals and weed management objectives.

Educational programs and prevention strategies address weed identification and techniques to limit weed spread. An IWM plan identifies high-quality (that is, areas with high desired plant cover) and valued areas and protects them from weed invasion and establishment—a key component in sustainable weed management. To forestall larger infestations, the IWM plan will guide identification and eradication of small weed patches.

Large infestations can persist and are very difficult and expensive to manage, and their development should be prevented in all cases. If infestations have developed, managers should work toward reestablishing

healthy plant communities by shifting the competitive balance from the weeds to the desired vegetation. This can be accomplished by reducing the competitive vigor of the infestation through combinations of mechanical, chemical, cultural (including revegetation) or biological methods—or all these methods in concert.

Frequent monitoring of the site and annual evaluations will determine the adequacy of the plan. Comparing data from one year to the next allows the manager to spot trends and patterns, and to identify and make changes needed to attain land management goals.

AFTER WILDFIRE

Appendix A. Montana County Noxious Weeds by Category

CATEGORY 1

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

Canada thistle (*Cirsium arvense*)
Dalmatian toadflax (*Linaria dalmatica*)
field bindweed (*Convolvulus arvensis*)
St. Johnswort (*Hypericum perforatum*)
whitetop/hoary cress (*Cardaria draba*)
sulfur (erect) cinquefoil (*Potentilla recta*)
leafy spurge (*Euphorbia esula*)
common tansy (*Tanacetum vulgare*)
Russian knapweed (*Acroptilon repens*)
oxeye daisy (*Chrysanthemum leucanthemum*)
spotted knapweed (*Centaurea maculosa*)
houndstongue (*Cynoglossum officinale*)
diffuse knapweed (*Centaurea diffusa*)

CATEGORY 2

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

Dyers woad (*Isatis tinctoria*)
meadow hawkweed complex (*Hieracium pratense*,
H. floribundum, *H. piloselloides*)
purple loosestrife or lythrum (*Lythrum salicaria*,
L. virgatum, and any hybrids)
tall buttercup (*Ranunculus acris*)
tansy ragwort (*Senecio jacobea*)
tamarisk (saltcedar) (*Tamarix* spp.)
orange hawkweed (*Hieracium aurantiacum*)

CATEGORY 3

Category 3 noxious weeds have either not been detected in the state or are to be found only in small, scattered, localized infestations. These weeds, which are known pests in nearby states, are capable of rapid spread, and render land unfit, have the highest management priority in Montana.

yellow starthistle (*Centaurea solstitialis*)
rush skeletonweed (*Chondrilla juncea*)
common crupina (*Crupina vulgaris*)

Appendix B. Rhizome-spreading Noxious Weeds of Montana

Canada thistle (*Cirsium arvense*)
common tansy (*Tanacetum vulgare*)
Dalmatian toadflax (*Linaria dalmatica*)
field bindweed (*Convolvulus arvensis*)
leafy spurge (*Euphorbia esula*)
meadow hawkweed * (*Hieracium pratense* [=*H. caespitosum*])
oxeye daisy (*Chrysanthemum leucanthemum*)
purple loosestrife † (*Lythrum salicaria*, *L. virgatum*, hybrids)
Russian knapweed (*Acroptilon repens*)
St. Johnswort (*Hypericum perforatum*)
sulfur (erect) cinquefoil (*Potentilla recta*)
tamarisk (saltcedar) (*Tamarix* spp.) ‡
whitetop/hoary cress (*Cardaria draba*)

* Vegetative expansion of meadow hawkweed is predominately through stolons, but sometimes through shallow underground rhizomes. •

† Purple loosestrife has adventitious buds arising on lateral roots; strict rhizome spread is questionable. •

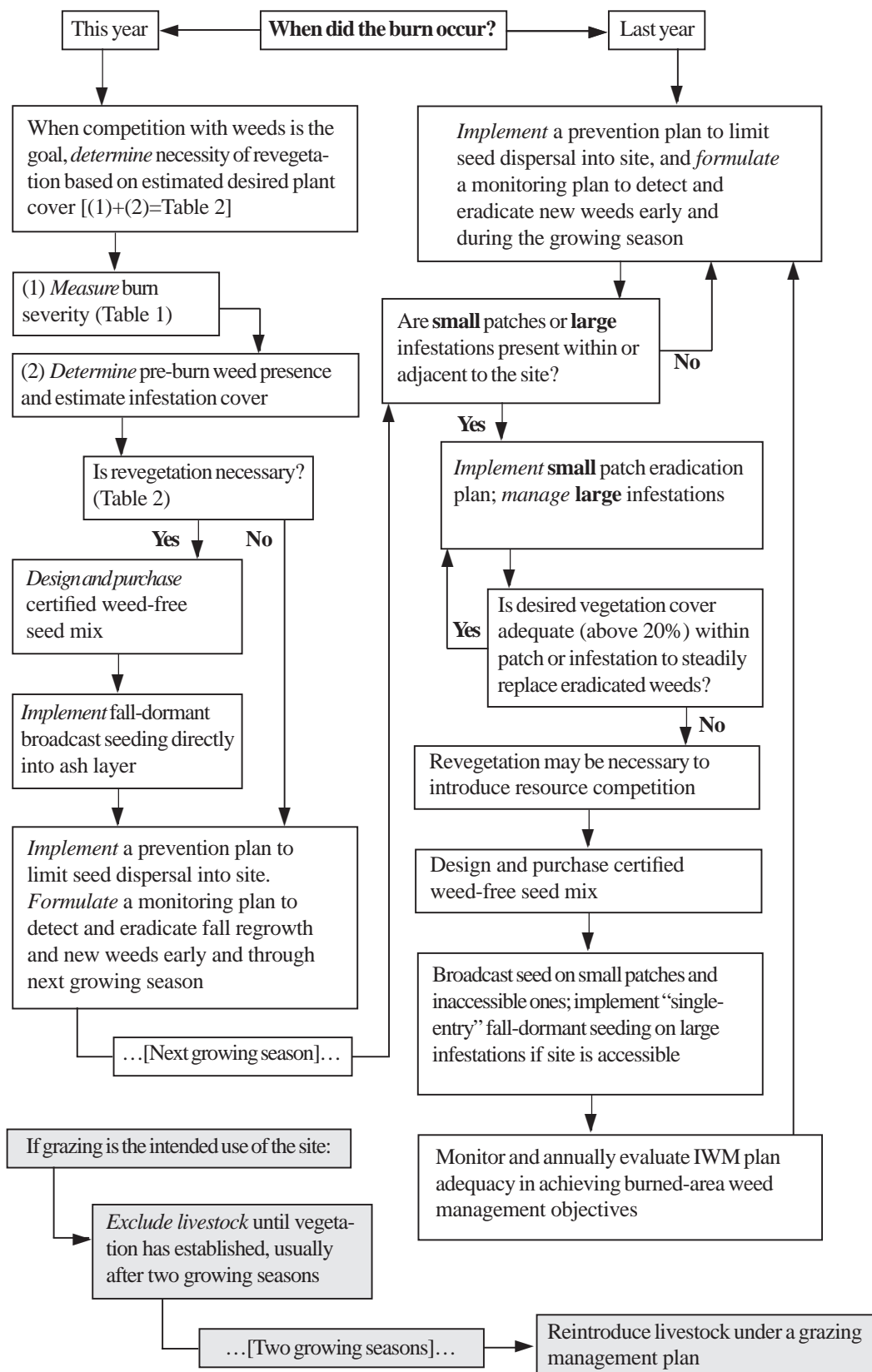
‡ Tamarisk can develop spreading horizontal roots after reaching the water table. These can spread up to 50m and are capable of producing adventitious buds.

1 Wilson, L.M. and R.H. Callihan. 1999. "Meadow and orange hawkweed." In: R.L. Sheley and J.K. Petroff (eds.) *Biology and management of rangeland noxious weeds*. Corvallis: Oregon State Univ. Press, 238–248.

2 USGS, Northern Prairie Wildlife Research Center. 1999. "Spread, impact, and control of purple loosestrife (*Lythrum salicaria*) in North American wetlands." www.npwrc.usgs.gov/resource/1999/loosstrf/biology.htm

Section 7—Rangeland Weed Management after Wildfire

Appendix C. Decision-making process to facilitate the formulation of a burned-area IWM plan



Revegetating After Wildfires

Appendix D.

FACT SHEET

MONTANA

What Areas Need Revegetating?

This depends on several factors:

- burn intensity: reflects the site's ability to recover quickly (See Fire Burn Intensity Classification page)
- slope: reflects the stability of the site
- weeds: will spread rapidly afterwards without competition from established vegetation
- proximity to drainages: channels, soils and vegetation in drainageways are very important for filtering runoff and handling increased flows and debris following fires
- management objectives: erosion control, reforestation, weed suppression, native plants

Revegetate with perennial grasses and forbs (slower establishment but long-term cover):

- Severely burned sites
- Moderately burned sites with...
 - less than 50' from a drainage channel, or ...
 - populations of noxious weeds before the fire

Revegetate with annual ryegrass or small grains (quick establishment but only one year of protection):

- Moderately burned sites with slopes above 15%
- Lightly burned areas less than 50' from a drainage channel

When Should I Plant?

Tree or shrub plantings: fall or early spring when plants are dormant.

Grasses and forbs: right after the fire or ground disturbance when the soil surface is loose. Seeding in late fall or early spring (even if there is a few inches of snow) improves success.

What Should I Plant?

Native vs. introduced species:

Use natives where reestablishing the native plant community is the primary objective. Use introduced species where stabilization and resource protection are the main objectives. **It is NOT recommended to mix native and introduced species because introduced specie seedings will not allow adequate establishment of native species (exception: slender wheatgrass).**

For stabilization and protection purposes, select plants based on how quickly they can grow, spread, and occupy harsh sites. Introduced species are generally quick to establish and provide cover. Native plants are adapted to the local climate and provide long-term soil protection, yet, generally are slower to establish.

(continued)

AFTER WILDFIRE

How Much Should I Plant?

Seeding/Planting rates:

Most seedings are broadcast with either aircraft or ground equipment.

Perennial species seeding rates:

- 80 seeds/sq. ft. (PLS) on severely burned sites;
- 40 seeds/sq. ft. (PLS) elsewhere.

(SLENDER WHEATGRASS SHOULD BE INCLUDED AT 20% TO 40% OF THE SEED MIX. This grass is quick to establish.) —Not suited for wet meadow sites.

Temporary seeding rates:

- annual ryegrass (NOT cereal rye) @ 10 lbs./ac. —Not suited for wet meadow sites.
- spring or winter grains @ 30 lbs./ac.

Spacing for bareroot or containerized plant material (staggered):

grass/grass-like/forb plugs2'x2' (11,000/ac)
shrubs <4' tall @ maturity.....4'x4' (2720/ac)
trees/shrubs >4' tall @ maturity.....10'x10' (436/ac)

Seed mixtures:

Plant several species of grasses and forbs to cover the range of site conditions and increase your chance of success. Recommend a minimum of 3 species in the mix. Always inoculate nitrogen-fixing plants.

Plant adapted species:

Refer to Table 1 for revegetating burn areas with plant species West of the Continental Divide and Foothills/Mountains East of the Continental Divide.

Use Table 2 for revegetating burn areas with plant species East of the Continental Divide.

Use certified seed of a known variety to get best results. If a specified variety is not available, be sure the seed originated within a 500-mile radius of your property. Be sure seed does not contain any noxious weeds. Contact the local Natural Resources Conservation Service, County Extension, or Conservation District offices for recommended varieties or substitute species.

Is There Anything Else to Help the Planting?

Mulch: Stabilize surface movement on small areas of steep (> 35%) slopes with straw mulch or netting. Apply mulch @ 70 lbs./1000sq. ft. Use weed free material. Do not fertilize the first year.

Maintenance: Repair any spots of failure with new seed, plants, and mulch. Fertilize after the first year in spring until vegetation is well established.

Table 1. Revegetating Burn Areas - West of the Continental Divide & Foothills/Mtns East of Divide

Zone 1. Dry, Warm Sites: Open grasslands and woodland benches, at low elevations on all aspects and on south and west-facing slopes at higher elevations. Dry Douglas-fir, limber pine, and ponderosa pine habitat types with a significant bunch grass component in the understory.

Zone 2. Moist, Warm Sites: Moderate environments receiving more effective precipitation than the dry, warm sites. Found on north and east-facing slopes on lower elevations, all aspects at mid-elevations, and on south and west-facing aspects at higher elevations. Douglas-fir and ponderosa pine habitat types.

Zone 3. Moist, Cool Sites: Found predominantly on north and east-facing slopes at mid-elevations and on all aspects at high elevations. Douglas-fir with blue huckleberry in the understory along with Grand fir, western cedar, western hemlock habitat types.

Zone 1. Dry, Warm Site:

Grass/forb species	lbs(PLS)/ac@40 seeds/sq.ft.
(N)Slender wheatgrass	12
(N)Thickspike wheatgrass	12
(N)Streambank wheatgrass	11
(N)Bluebunch wheatgrass	12
(N)Big bluegrass	2
(I)Pubescent wheatgrass	22
(I)Sheep fescue	3
(I)Hard fescue	3
(I)Yellow sweet clover*	(no more than 1/2 lb/ac)
(I)Dryland alfalfa varieties*	(no more than 1/2 lb/ac)

Native tree/shrub species (Zone 1)

Trees: Ponderosa pine-west/east, Douglas-fir-west/east;
Shrubs <4 ft: Snowberry, Woods rose, Antelope bitterbrush, Skunkbush sumac; Shrubs >4 ft: Mountain mahogany, Mockorange, Chokecherry

Zone 2. Moist, Warm Site:

Grass/forb species	lbs(PLS)/ac@40 seeds/sq.ft.
(N)Slender wheatgrass	12
(N)Thickspike wheatgrass	12
(N)Streambank wheatgrass	11
(N)Beardless wheatgrass	12
(N)Big bluegrass	2
(N)Mountain brome	27
(I)Intermediate wheatgrass	22
(I)Nevada bluegrass	2
(I)Sheep fescue	3
(I)Hard fescue	3
(I)Orchardgrass	4
(I)Timothy	2
(I)White Dutch, red, or white clover*	2
(I)Yellow sweet clover*	(no more than 1/2 lb/ac)
(I)Alfalfa*	(no more than 1/2 lb/ac)
(I)Sanfain*	(no more than 4 lbs/ac)

Native tree/shrub species (Zone 2)

Trees: Ponderosa pine-west/east, Douglas-fir-west/east, Western larch; Shrubs <4 ft: Snowberry, Woods rose, Currant; Shrubs >4 ft: Serviceberry, Rocky Mountain maple

Zone 4. Riparian Areas: Stream bottoms, wet meadows. These sites are subirrigated or wetter for at least a portion of each growing season.

Seeding rates by zone:

The following are "pure-stand" seeding rates for each species expressed as pounds pure live seed (PLS) per acre. To calculate a mix, divide the individual specie rate by the number of species in the mix. Then take the lbs./ac. and multiply by the total acres to be seeded.

Example: Mix of 4 grasses to be seeded on 10 acres: divide the lbs./ac. for each species by 4, and then multiply by 10. For slender wheatgrass: (12/4)10 = 30.

Double these rates for severely burned areas.

Zone 3. Moist, Cool Site:

Grass/forb species	lbs(PLS)/ac@40 seeds/sq.ft.
(N)Slender wheatgrass	12
(N)Beardless wheatgrass	12
(N)Big bluegrass	2
(N)Tufted hairgrass	1
(N)Mountain brome	27
(I)Intermediate wheatgrass	22
(I)Orchardgrass	4
(I)Sheep fescue	3
(I)Hard fescue	3
(I)Nevada bluegrass	2
(I)Timothy	2
(I)Alsike, red, or white clover*	(no more than 1/2 lb/ac)
(I)Birdsfoot trefoil*	(no more than 1/2 lb/ac)

Native tree/shrub species (Zone 3)

Trees: Douglas-fir-west, Western larch, Engelmann spruce; Shrubs >4 ft: Scouler's willow, Red-osier dogwood, Alder, Rocky Mountain maple

Zone 4. Riparian Areas

Stream Bottoms (>2' water table)

Grass/sedge/forb species	lbs (PLS) /ac@40seeds/sq.ft.
(N)Slender wheatgrass	12
(N)Basin Wildrye	2
(I)Meadow foxtail	2
(I)Birdsfoot trefoil*	(no more than 1/2 lb/ac)
(I)Alsike clover*	(no more than 1/2 lb/ac)

Wet Meadows (< 2' water table)

(N)Native Sedge species (plugs/ac)	11,000
(N)Native Rush species (plugs/ac)	11,000
(N)Tufted hairgrass	1

Native tree/shrub species (> 2' water table) (Zone 4)

Trees: Black cottonwood, Quaking aspen, Engelmann spruce; Shrubs <4 ft: Snowberry, Woods rose
Shrubs >4 ft: Native willow species, Red-osier dogwood, Chokecherry, Mockorange, Rocky Mountain maple, Water birch, Alder, Serviceberry

(N) Native; (I) Introduced

*Nitrogen-fixing

AFTER WILDFIRE

Table 2. Revegetating Burn Areas - East of the Continental Divide

Double these rates for severely burned areas.

DRY ENVIRONMENT

Ponderosa Pine/Little bluestem, bluebunch wheatgrass dominated.

1) Reduce Tree Seedling Competition/Low Forage Value.

"Covar" sheep fescue (introduced)	3	lbs./Ac. PLS @ \$3.30 = \$09.90	46.8 seeds/sq. ft.
"Pryor" slender wheatgrass (native)	2	lbs./Ac. PLS @ \$1.35 = <u>\$02.70</u>	<u>6.4</u> " "
		\$12.60/Ac.	53.2

2) Reduce Tree Seedling Competition/Moderate Forage Value.

"Sherman" big bluegrass (native)	2	lbs./Ac. PLS @ \$6.20 = \$12.40	40.5 seeds/sq. ft.
"Pryor" slender wheatgrass (native)	2	lbs./Ac. PLS @ \$1.35 = <u>\$02.70</u>	<u>6.4</u> " "
		\$15.10/Ac.	46.9

3) Maximum Cover/High Forage Value.

"759" pubescent wheatgrass (introduced)	9	lbs./Ac. PLS @ \$1.25 = \$11.25	16.5 seeds/sq. ft.
"Covar" sheep fescue (introduced)	1.5	lbs./Ac. PLS @ \$3.30 = \$04.95	23.4 " "
"Pryor" slender wheatgrass (native)	2	lbs./Ac. PLS @ \$1.35 = <u>\$02.70</u>	<u>6.4</u> " "
		\$18.90/Ac.	46.3

4) Maximum Cover/Moderate Forage Value.

"Critana" thickspike wheatgrass (native)	5	lbs./Ac. PLS @ \$5.55 = \$27.75	16.6 seeds/sq. ft.
"Covar" sheep fescue (introduced)	1.5	lbs./Ac. PLS @ \$3.30 = \$04.95	23.4 " "
"Pryor" slender wheatgrass (native)	2	lbs./Ac. PLS @ \$1.35 = <u>\$02.70</u>	<u>6.4</u> " "
		\$35.40/Ac.	46.4

MODERATE ENVIRONMENT

Ponderosa pine/green needlegrass, Columbia wheatgrass, tall bluestem, common snowberry, Oregon grape dominated.

5) Maximum Cover/Moderate Forage Value.

"Critana" thickspike wheatgrass (native)	5	lbs./Ac. PLS @ \$5.55 = \$27.75	16.6 seeds/sq. ft.
"Durar" hard fescue (introduced)	1.5	lbs./Ac. PLS @ \$3.30 = \$04.95	19.4 " "
"Pryor" slender wheatgrass (native)	2	lbs./Ac. PLS @ \$1.35 = <u>\$02.70</u>	<u>6.4</u> " "
		\$35.40/Ac.	42.4

6) Maximum Cover/High Forage Value.

"Rush" intermediate wheatgrass (introduced)	9	lbs./Ac. PLS @ \$1.25 = \$11.25	16.3 seeds/sq. ft.
"Durar" hard fescue (introduced)	1.5	lbs./Ac. PLS @ \$3.30 = \$04.95	19.4 " "
"Pryor" slender wheatgrass (native)	1	lbs./Ac. PLS @ \$1.35 = <u>\$02.70</u>	<u>6.4</u> " "
		\$18.90/Ac.	42.1

MOIST ENVIRONMENT

Ponderosa pine/common snowberry, common chokecherry, russett buffaloberry, Oregon grape, kinnikinnick dominated.
(Use mix #6 or #7)

7) Reduced Tree Seedling Competition/High Forage Value.

"Paiute" orchardgrass (introduced)	3	lbs./Ac. PLS @ \$1.35 = \$04.05	32.0 seeds/sq. ft.
"Durar" hard fescue (introduced)	1.5	lbs./Ac. PLS @ \$3.30 = \$04.95	19.4 " "
"Pryor" slender wheatgrass (native)	1	lbs./Ac. PLS @ \$1.35 = \$01.35	6.4 " "
		\$10.35/Ac.	57.8

* Prices subject to change based on supply.

Contact your local Conservation District or NRCS office for further information, technical assistance, and sources of seed and plant materials.

Additional Reading

- Carpinelli, M. 2000. "Designing weed-resistant plant communities by maximizing niche occupation and resource capture." Ph.D. diss., Montana State University, Bozeman.
- Hansen, R. 1993. "Effects of Aphthona flea beetles and sheep grazing in leafy spurge stands." Proc. 1993 Leafy Spurge Symposium, Silvercreek, Colo.
- Glimp, H.A. 1988. "Multi-species grazing and marketing." *Rangelands* 10:275–78.
- McGinnies, W. J. 1987. "Effects of hay and straw mulches on the establishment of seeded grasses and legumes on rangeland and a coal strip mine." *J. Range Manage.* 40(2):119–121.
- Rice, P. and R. Sacco. 1995. "Spotted knapweed response to burning, a brief review." Unpublished report.
- Sheley, R. and B. Roché. 1982. "Rehabilitation of spotted knapweed infested noxious in north-eastern Washington." Abstr. of Papers. Denver: W. Soc. Weed Sci.
- Sheley, R.L. and J.K. Petroff (eds.). 1999. *Biology and management of noxious rangeland weeds*. Corvallis: Oregon State Univ. Press.
- USDA Forest Service. 2000. "A preliminary assessment of the extent and effects of the 2000 fires, Intermountain and Northern Regions."
- Selected MSU Extension Publications
- "Biocontrol of spotted knapweed" MT199915AG
- "Leafy Spurge: Ecology, Biology & Management" EB0134
- "Soil, plant and water analytical laboratories for Montana agriculture" EB150
- "Monitoring Montana Rangeland" 2B0369
- "Montana's noxious weeds" EB159
- "Mowing to manage noxious weeds" MT200104AG
- "Oxeye daisy" MT200002AG
- "Preventing noxious weed invasion" MT199517AG
- "Rangeland weed management" MT199504AG
- "Revegetating weed-infested rangelands with a single field entry" MT199912
- For these and other, related MSU Extension publications, go to <http://www.montana.edu/publications>

Acknowledgments

We would like to acknowledge the reviewers and editors of this bulletin, and to thank them for their contributions: Dave Burch, Reggie Clark, John Day, Jack Eddie, Scott Freutel, Larry Hoffman, Larry Holzworth, Rob Johnson, Andy Kulla, Bob Logar, Marty Malone, Barbra Mullin, Jim Olivarez, Monica Pokorny, Sharon Sconamilio, Suzi Taylor and Jennifer Vollmer. —k.g.,r.s.,j.c.

AFTER WILDFIRE — Information for landowners coping with the aftermath of wildfire

James E. Knight, editor

Extension Agriculture and Natural Resources Program

Montana State University, Bozeman

This book provides information to help landowners cope with the aftermath of future wildfires in Montana and in other states. Each section can be copied and distributed as needed. To obtain a copy of this publication or any of the following sections, please contact your local Montana State University Extension agent or download a PDF file at www.montana.edu/publications.

- | | |
|-----------|---|
| Section 1 | Tools to Assist in Economic Decision Making After Wildfire |
| Section 2 | Management Strategies for Beef Cattle After Drought or Wildfire |
| Section 3 | Water Quality Concerns After Wildfire |
| Section 4 | Tree and Forest Restoration Following Wildfire |
| Section 5 | Reestablishing Pasture and Hay Meadows After Wildfire |
| Section 6 | Electric Fencing to Exclude Deer and Elk from Recovering Burned Areas |
| Section 7 | Rangeland Weed Management after Wildfire |
| Section 8 | Tax Implications of Farm Business Property Destroyed by Wildfire |

Copyright © 2002 MSU Extension Service

To order additional copies of this or other publications, call your local county or reservation Extension office, or visit www.montana.edu/publications. We encourage the use of this document for nonprofit educational purposes. This document may be reprinted if no endorsement of a commercial product, service or company is stated or implied, and if appropriate credit is given to the author and the MSU Extension Service. To use these documents in electronic formats, permission must be sought from the Ag/Extension Communications Coordinator, Communications Services, 416 Culbertson Hall, Montana State University-Bozeman, Bozeman MT 59717; (406) 994-2721; e-mail - publications@montana.edu.



The programs of the MSU Extension Service are available to all people regardless of race, creed, color, sex, disability or national origin. Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, David A. Bryant, Vice Provost and Director, Extension Service, Montana State University, Bozeman MT 59717.