2001

Integrated Noxious Weed Management After Wildfires

Natural Resources Conservation Service

Integrated Noxious Weed Management *after* Wildfires

Introduction

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 oflow severity, we now experience damaging fires that can be both intense and severe.

Severe fires 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 is typically recommended in areas that suffered a very severe fire, or that had a high degree of noxious weed cover before the fire, or both. Revegetation of these areas will be necessary as a result of low desired plant survival and pre-burn cover.

Revegetation isn't always indicated, however. It is typically not necessary in burned areas that experienced a low- to medium-severity fire, especially when the pre-burn noxious weed cover was low to moderate with adequate vegetation cover. Such burned areas are likely to recover without revegetation if the land manager follows good weed management practices—prevention, detection and eradication. Established populations will require long-term management that includes mechanical, chemical, cultural and sometimes biological control efforts. Then too, revegetation 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.

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 and maintain healthy plant communities.

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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.

Deciding whether or not to revegetate is best done soon after the fire, typically in the fall. If this decision is delayed, weed management based on a burned-area plan should begin in the spring with revegetation, if needed, following in the fall.

Burn severity & 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.

As a rule, plants that can sprout from roots, from soil surface crowns, and from rhizomes survive fire better than plants that reproduce strictly from seed. However, seeds produced by plants that evolved with frequent fires, such as lodgepole pine (*Pinus contorta*), are tolerant of higher fire temperatures and actually require heat to germinate. Small, low-growing plants often survive because they contain little fuel and are close to the ground, where fire temperatures are usually lower than elsewhere. Brief

Table 1. Determining burn severity

Adapted from "Fire Burn Severity," Gallatin National Forest [unpublished]

Burned area characteristics—	**Low severity**	**Medium severity**	**High severity**
Soil color and condition	Normal color; soil is not physically affected	Up to 2" of soil darkened brown to reddish-brown below the duff or ash layer; soil is not physically affected	2" to 4" of soil is darkened reddish-orange; soil can be physically affected; crusted, crystallized, and/or agglomerated
Duff and debris	Duff and debris partly burned	Duff consumed; burned debris (e.g. needles) still evident	Duff and debris entirely consumed
Ash characteristics	Generally dark-colored	Dark-colored ash present	Uniformly gray/white ash present; in severe cases, ash is white and light
Hydrophobicity[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
Shrub stump, small fuels condition	Slightly charred	Charred but still present	Entirely absent
Plant survival[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
Recovery potential[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 non-pliable. Plant survival is also a factor of seed viability in the soil.

3. Delayed recovery time likely with moderate to high noxious weed cover.

exposures to high fire temperatures are less damaging than extended exposures. Plant survival can also be influenced by its growth stage at the time of the fire.

Noxious weed cover & 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.

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.

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 even very severe fires.

When fire removes a rhizomatous weed's top growth, it stimulates the production of new shoots from the vegetative root buds. Because of nutrient reserves in the roots, these new shoots are immediately aggressive and highly competitive. Fires also expose ground surfaces, cause a flush of nutrients and create conditions of high light and low shade. All of these effects can result in the rapid growth and expansion of weeds in burned areas.

Weed seeds and crowns can survive most fires. Because of their early germination and rapid growth rates, weeds quickly capture newly available resources. In 1982, for instance, a single, low-intensity fire increased the cover and density of spotted knapweed (*Centaurea maculosa*) in northern

Washington. Similarly, on a forested site in Montana, spotted knapweed 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.

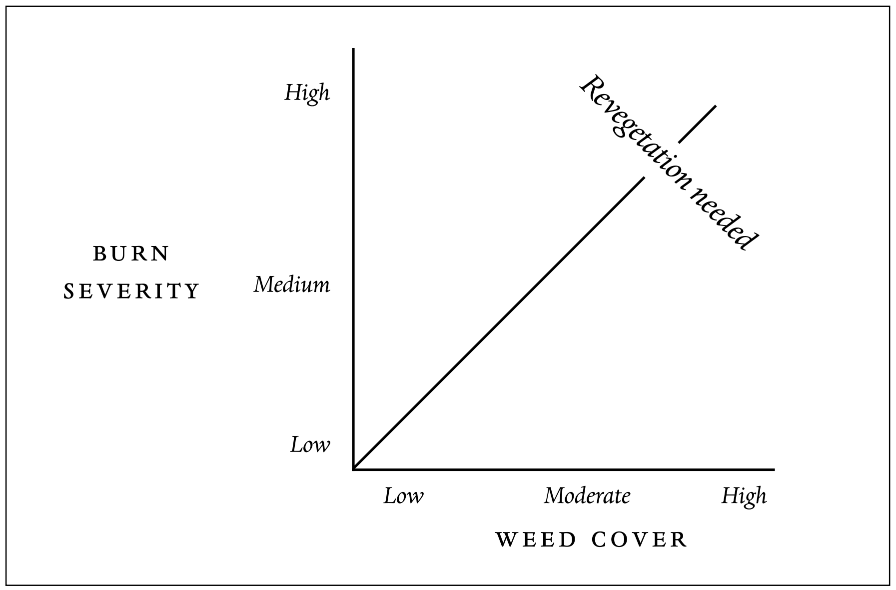

Fig. 1. This simple chart shows how increased burn severity and weed cover indicate the necessity for revegetation.

Table 2. Determining the necessity of burned-area revegetation

Degree of noxious weed cover	Burn severity—		
	Low	**Medium**	**High**
Absent to low—up to 20% weed cover (i.e., rare to regularly scattered weed occurrence) *High pre-burn cover of desired vegetation*	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) *Moderate pre-burn cover of desired vegetation*	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) *Low to absent pre-burn cover of desired vegetation*	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.

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.

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Revegetating, Establishing & 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 box opposite).

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.

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.

"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.

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*

The goal of revegetating is to speed recovery of a healthy and competitive plant community. Such a community uses most soil resources, leaving few for potential invaders. For example, a seed mix designed to maximize the occupation of niches by desired plants and minimize the occupation of niches by noxious weeds will typically include species that grow both early and late in the year, and that take up a good deal of soil profile space. An important constituent might be cool-season grasses that use soil resources available in the upper soil profile to initiate their growth in late winter and early spring and begin seed production in early summer.

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 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. 39–45.)

Money & effort spent on revegetation will be wasted unless management practices favor the desired species that were seeded.

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 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 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.

Transplanting mature plants from the local landscape into the burned area can complement reseeding and increase the overall success of revegetation by providing rapid plant establishment. Nursery stock is costly, though. Costs can be reduced by transplanting individual plants from local landscapes or by planting fewer individuals in "islands" where a central, established stand of plants can reproduce and eventually spread throughout the burned area.

Seedbeds & seeding methods

If they're reseeded 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 or drill. This preparation, which makes more 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 competitive plants

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 such as lupine 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.

Noxious weeds can spread within rangeland systems for two main reasons:

· the grazing preferences of cattle can affect plant community succession, and
· heavy grazing practices.

Effects of grazing on plant community succession

As a general rule, domestic sheep prefer broad-leaved plants (forbs) to grasses, and cattle prefer grasses to forbs. In grazed areas, these preferences shift the composition of species within plant communities. Cattle, the dominant grazer in many of Montana's ecologic systems, selectively forage grasses while usually neglecting forbs—including introduced, invasive forbs (noxious weeds). As a result, grasses are at a disadvantage in competing for limited soil, water and nutrients when weeds are present. This leads to a predominance of noxious weeds within many grazing systems. The problem can be mitigated, in many cases, by multispecies grazing with domestic sheep.

In many rangeland systems west of the Continental Divide, perennial grasses have long dominated the climax vegetation state, coexisting with a minor native forb and shrub component. But because cattle usually disregard forbs and shrubs and persistently graze grasses, many rangeland systems have regressed to shrub-and-forb communities—communities that may include noxious weeds.

In contrast to cattle, domestic sheep assist in the successional process toward a perennial grass community by usually avoiding grasses and instead applying grazing pressure on native forbs and noxious weeds. To balance grazing pressure and direct succession toward a climax state, consider incorporating domestic sheep into grazing systems. On moderately stocked rangelands, one ewe can be added per cow without reducing cattle production.

Heavy grazing

In many rangeland systems the spread of weeds can be attributed, in part, to heavy grazing. Native rangeland plants did not evolve under heavy grazing pressure. As a result, they are relatively intolerant of high grazing levels, especially during the growing season. Heavy grazing stops growth and reduces grass vigor by affecting carbon fixation. This places a great disadvantage upon the grazed plant when it is competing with an ungrazed weed for soil resources. For example, researchers in eastern Washington found the establishment of diffuse knapweed (*Centaurea diffusa*) was enhanced only when defoliation of the native bluebunch wheatgrass (*Pseudoroegneria spicata* spp. *spicata*) exceeded 60 percent, suggesting that defoliation past this level reduced the grass's competitiveness.

The spread of noxious weeds into or within grazing systems can be prevented or minimized through proper management of competing plants. Part of such management is avoiding heavy grazing and considering the inherent preferences of domestic grazers and how those preferences shape plant community succession.

Devising a grazing program

Proper grazing management encourages continued growth and vigor of the competitive plant community. This reduces the potential for weed invasion and suppresses weed establishment and growth.

Multispecies grazing can be integrated into a grazing 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 may also include 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.

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Integrated Weed Management

INTEGRATED WEED MANAGEMENT (IWM) is a multidisciplinary, ecological approach to preventing and managing weeds. An IWM plan is both practical and holistic; it typically incorporates a combination of preventive strategies and management techniques that shape the composition and structure of the plant community to promote a healthy ecosystem.

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 and maintaining 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. Example might include,"identify and eradicate new invaders over the next three years," "prevent weed invasion, establishment and growth in weed-free areas over the next three years," and "eradicate small patches by preventing reproduction while steadily replacing removed weeds with desired plants over the next three years."

The goal of IWM is the development and maintnance of healthy, desired plant communities.

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.

The key components of a burned-area IWM plan are—

- *Sustained effort*
- *The adoption of new and improved strategies as they become available*
- *The utilization of as many appropriate techniques as possible, since reliance on just one method frequently results in failure, and*
- *Regular monitoring with annual evaluation.*

To compile a plan, see Appendix C, *p. 38.*

- 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 noxious weed establishment. If a weed patch becomes a large-scale infestation, it can be difficult and expensive to manage. Incorporating a systematic monitoring program within a burned-area IWM plan permits the early identification and eradication of new weeds and small patches that might otherwise become large infestations.

It is important to be able to identify weeds, especially in their seedling stage, when most weeds are especially vulnerable to control measures. For instance, Dalmatian toadflax (*Linaria dalmatica*) is a poor competitor as a seedling. But once this period of vulnerability has passed and vegetative growth begins, this weed becomes an extremely aggressive competitor.

Other periods of vulnerability for noxious weeds include the early bud and fall regrowth stages. Treatment during such periods with appropriate herbicides can kill the weed or greatly reduce its vigor through herbicide translocation to its roots. Taking advantage of these periods of vulnerability can significantly enhance management efforts.

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.

Monitoring & 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 (see p. 27) 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.

Many weed monitoring plans rely upon individuals to identify weed locations through sighting reports. But such reports are typically not uniform. Coverage is often spotty; areas near roads and trails are typically better-documented than outlying lands. A good monitoring plan ensures that weed surveys are thorough and frequent.

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-pulled or dug up or treated with an appropriate herbicide.[1]
- *Summer* Examine the area again during the early bud stage to eradicate any previously overlooked weeds. Preventing seed dispersal is critical; applying herbicides after the late flowering stage generally won't prevent seed production.

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.

- *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 within or adjacent to the burned area. Components of such a program might include:

- Prioritizing your management efforts. Begin by locating and determining the size and density of weed patches. 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 the 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 burned 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. Proper timing is predicated mainly on the growth stage of the infestation, secondarily on the growth stage of the desired plants. Long-term repeated mowing can eventually deplete root reserves; once this point is reached, revegetation may enhance the establishment of desired plants.

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, 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

Containing 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 burned areas.

Large infestations should be managed toward reestablishing healthy plant communities (see p. 10f.). 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.

Rhizomatous weeds & fire

Noxious weeds will increase growth as a result of survival coupled with fire-produced disturbances. Growth of rhizomatous weeds (see Appendix B, p. 37) 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.

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.

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 also 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.

Ash dust can neutralize glyphosate, usually the chemical of choice when establishing desired vegetation.

An option is to revegetate the area and treat weeds prior to seedling emergence or after establishment.

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.

Suitability for the target weed, considerations of proximity to surface and ground water, and close adherence to herbicide label directions are the absolute minimum considerations in selecting an herbicide.

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 will ensure the translocation of the herbicide to roots or rhizomes.

Soil-residual herbicides persist and continue to affect newly emerging plants or sprouting perennial shoots.

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.

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

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 reseeding. 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.

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 and proper management of desired plants.

Revegetation is an essential IWM plan component when the desired vegetation cover is inadequate to fill available niches within an infestation.

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 2, p. 9). *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.

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 plant community. 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.

Containment programs restrict the encroachment of large-scale weed infestations.

"Single-entry" revegetation

Traditionally, successful revegetation of areas heavily infested by weeds has been an expensive multi-attempt, multi-entry approach. Establishing the 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 wheatgrass 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

Central to managing large infestations through grazing is the choice of the appropriate grazing animal.[1] This is determined by considering the animals' dietary preferences and the effect of those preferences on plant community succession.

Domestic 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.

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.

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 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.

1 To speed the recovery of vegetation, it's a good idea to exclude livestock from burned areas until after vegetation has reestablished—usually for two growing seasons.

Table 3. Selected biological control agents

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

BIOLOGICAL CONTROL

The noxious weeds of Montana (see Appendix A) 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 low and relatively 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. Once the agents have been established, there should be no recurring annual costs. As a result, biological control can be an economical, long-term solution to some large infestations.

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. Heightened seedling establishment can occur as a result of diminished weed competitiveness and through occupation of the open niches made available by the removed weeds.

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.

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 of the managed weeds 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 many cases, to the more detailed monitoring and evaluation strategies that make use of transects.

Long-term success of burned-area management requires that managers continuously monitor and evaluate the area to adjust management practices to direct plant community succession toward a desired plant community.

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 with a measuring tape (for small patches) 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 ½-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 restablishment 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. 38) 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.

Additional Reading

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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

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 (T*anacetum 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*)

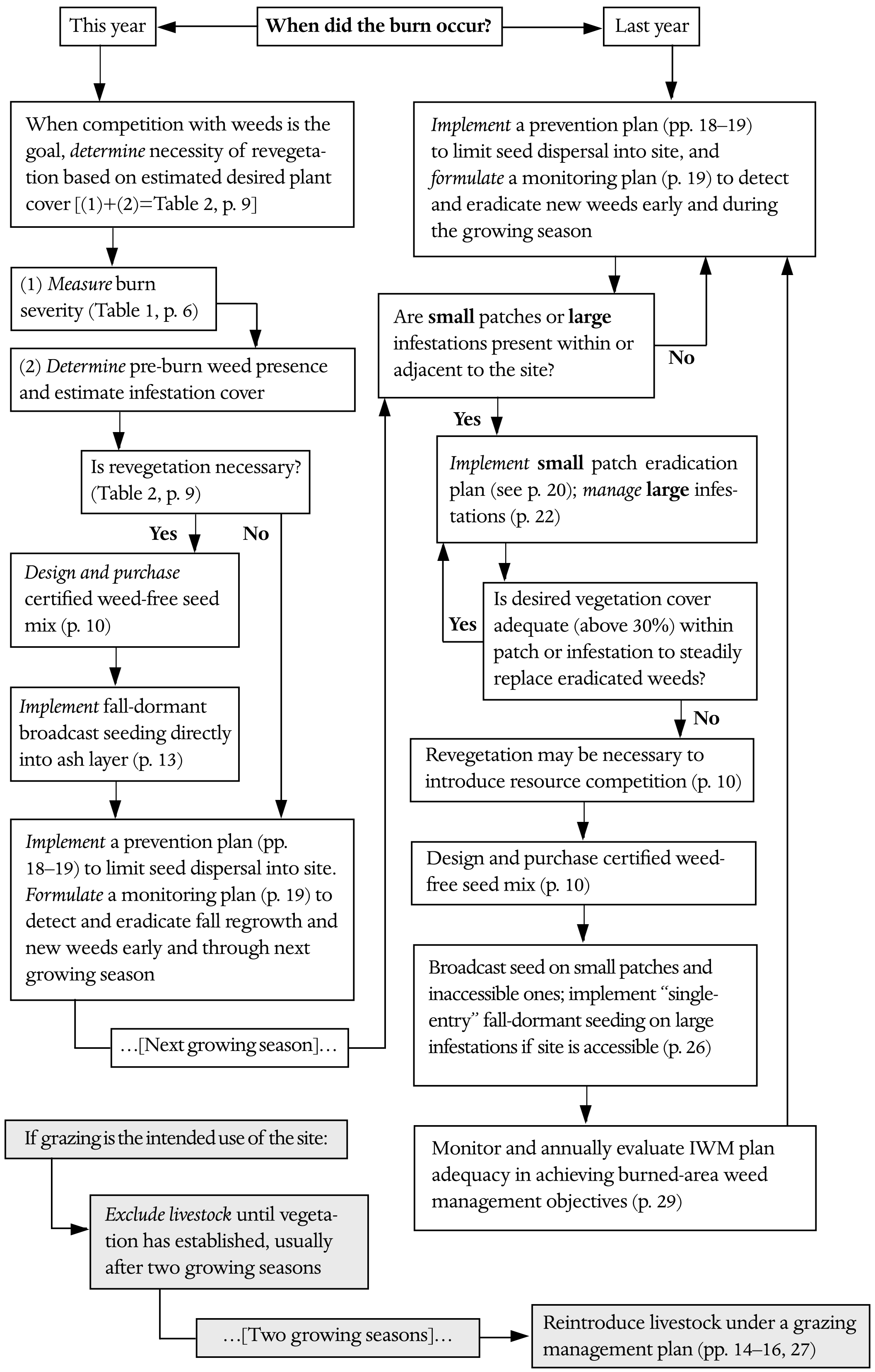
* Vegetative expansion of meadow hawkweed is predominately through stolons, but sometimes through shallow underground rhizomes.[1]

† Purple loosestrife has adventitious buds arising on lateral roots; strict rhizome spread is questionable.[2]

‡ 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**

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



Appendix D

Revegetating After Wildfires

FACT SHEET **MONTANA**

USDA NRCS

United States Department of Agriculture

Natural Resources Conservation Service

August 2000

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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.

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 plugs ....2' x 2' (11,000/ac)
shrubs <4' tall @ maturity ....4' x 4' (2720/ac)
trees/shrubs >4' tall @ maturity....10' x 10' (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

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.

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 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. In the zone charts below, starred items (*) are nitrogen-fixing.

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

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

continued

Table 1 ***continued***

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)Sanfoin*	(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 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

Table 1 ***continued***

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

continued

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 (*introdzuced*)					
3 lbs/ac PLS @	$ 3.30	=	$ 09.90	46.8	seeds/sq. ft.
"Pryor" slender wheatgrass (*native*)					
2 lbs/ac PLS @	1.35	=	02.70	6.4	" "
			$ 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	=	02.70	6.4	" "
			$ 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*)					
2lbs/ac PLS @	1.35	=	02.70	6.4	" "
			$ 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	=	02.70	6.4	" "
			$ 35.40/ac	**46.4**	" "

Note: Prices subject to change

Table 2 *continued*

DRY ENVIRONMENT *continued*
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	=	$ 27.70	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	=	02.70	6.4	" "
			$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 lb/ac PLS @	1.35	=	02.70	6.4	" "
			$18.90/ac	**42.1**	" "

MOIST ENVIRONMENT
Ponderosa pine/common snowberry, common chokecherry, russett buffaloberry, Oregon grape, kinnikinnick dominated

Use mix No. 6, above, or No. 7, below:

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**	" "

Note: Prices subject to change

continued

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

As of August 2002
the NRCS Montana State office
main telephone number is
(406) 587–6811

The NRCS main Web site URL is
www.nrcs.usda.gov/

Appendix D is a NRCS publication prepared by
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