AFTER WILDFIRE

Information for landowners coping with the aftermath of wildfire

4455

MONTANA STATE UNIVERSITY EXTENSION

Megan Van Emon, Editor
Extension Beef Cattle Specialist,
Department of Animal and Range Sciences, Montana State University

Table of Contents

MONTANA STATE UNIVERSITY EXTENSION

Cover photo by Sheron Curry

Economic Decisions After Wildfire

Duane Griffith, *retired Extension Farm Management Specialist, Department of Agricultural Economics and Economics, Montana State University*
Updated by Kate Fuller, *Extension Farm Management Specialist, Department of Agricultural Economics and Economics, Montana State University (August 2017)*

The economic impacts of a wildfire vary tremendously between individual farmers and ranchers. The time of year, type and amount of property lost, and possible remedies affect what courses of action are taken. This article cannot begin to cover the various details involved for individual producers. The intent here is to provide methods for working through an analysis process for individual decisions on each operation.

Two useful resources in this process are the Montana State University Extension Software Downloads page (montana.edu/softwaredownloads/) and the Iowa State University Extension Ag Decision Maker site (www.extension.iastate.edu/agdm). Analysis tools listed below can be found in on either or both of these websites, unless one is specifically mentioned.

Farm Service Agency Disaster Assistance

Several disaster assistance programs are available to help producers who have suffered losses from fire, drought, or other natural disasters. These include compensation for grazing loss or excess death loss. To determine if you qualify, contact your local FSA office. Location and contact information can be found here: https://offices.sc.egov.usda.gov/locator/.

Loss of machinery or equipment

When machinery or equipment is completely destroyed by wildfire, you may want to consider alternative forms of accomplishing the same task. For example, if a tractor and baler is lost in a fire, the producer must still accomplish the task of baling straw, hay or other crops. The question becomes, "What is the most economical way to accomplish this task?" The basic options are owning, leasing, or hiring out the operation. Which method is most economical?

Analysis tools

Tools to help estimate the relative costs and returns of owning vs. leasing equipment vs. hiring out jobs are a good place to start. Machine cost calculators can help fill in operating and ownership costs of equipment if you have not yet estimated them.

Loss of feed (grazing or hay)

Depending on the circumstances of a wildfire, the loss may not cause a significant impact. For example, if the fire occurs at the end of a summer grazing season on pasture that would not be used until the following summer, the impact may be small. But things don't always happen this way. Forage, grazing and hay may need to be replaced for some or all of the livestock. How would this impact this year's cash flow needs and profitability of the operation?

Analysis tools

To answer these types of questions, producers can use and analyze financial worksheets. A cash flow statement is a good place to start. Fill in cash inflows and outflows to date, then estimate what additional cash inflows (insurance or other types of reimbursements) or cash outflows (expenses to replace grazing and other lost forage or crops) may occur for the remainder of the production period. This can help plan for financial needs as a result of losses due to fire or other catastrophes.

Other financial statements that may be useful include balance sheets, income statements, and statements of owner equity. Working through these can provide analysis of all financial impacts on the operation. They can be used to analyze the effects that various strategies for recovering from a wildfire may have on cash flow, profitability and equity. If losses from a fire are severe enough, an operation's ability to survive in the long term may be significantly affected.

Enterprise analysis

A loss of resources from fire often affects short-term decisions about various enterprises within an operation. Long-term implications are also possible. One example may be deciding to retain calves in the fall for overwintering and graze them in the spring and summer. If additional forage (either grazing or hay) must be purchased, the cost of spring and summer grazing could affect the profitability of retaining the calves in the fall.

Analysis tools

Two tools available to help producers look at the profitability of specific situations are CalfWinter and Grassfat on the MSU Extension Software Downloads page. The CalfWinter template analyzes the profitability of keeping calves through the winter. This analysis is not restricted to on-farm feeding. The program will handle most scenarios that might occur with retained ownership of calves through the winter. The GrassFat program analyzes alternatives that may occur when producers put over-wintered calves on grass for the summer.

Destruction of Property

A fire can cause significant destruction of property (machinery, equipment, buildings, livestock, etc.). Depending on the property destroyed, the loss may impact one enterprise more than another. Producers may want to do long-term enterprise budgeting to see effects on a particular enterprise. An example may be the loss of all livestock-related buildings, and of machinery and equipment related to livestock enterprises.

Looking forward: Crop, Livestock, and Other Insurance Products

A fire event, and possibly drought conditions surrounding it, may lead to a discussion about current and future risk management strategies. One often-forgotten but important point is that losses due to fire may not be covered by a federal crop insurance policy – unless the fire started because of lightning…or a volcano. Fire-only coverage is relatively inexpensive and available for certain crops in Montana. The MSU Crop and Livestock Insurance website (msuextension.org/cropinsurance/) is a good place to learn about available policies.

Management Strategies for Beef Cattle after Drought or Wildfire

John Paterson, *retired Extension Beef Cattle Specialist, Department of Animal and Range Sciences, Montana State University*
Greg Lardy, *Department Head, Department of Animal Sciences, North Dakota State University*
Rick Funston, *former Extension Beef Cattle Specialist, Department of Animal and Range Sciences, Montana State University*
Ron Carlstrom, *former Gallatin County Extension Agent, Montana State University Extension*
Updated by Megan Van Emon, *Extension Beef Cattle Specialist, Department of Animal and Range Sciences, Montana State University (August 2017)*

Drought develops progressively over time – wildfire is more immediate. However, many of the decisions a rancher must make are similar, whether the situation is caused by drought or by results of a wildfire. Management of a ranch during either drought or after a fire depends on the balance between stocking density and availability of feed and water. In the long run, you can help protect your interests by planning to make ranch decisions less sensitive to these challenges. Early decisions need to be based on what relief measures are potentially available on the ranch. Among the important factors are guessing the expected duration of the drought or effects of the fire, current water and feed inventories, body condition of the cowherd and financial resources available. During drought or after wildfire, decisions may be based on emotion rather than logic. The main goal is to make objective decisions and get skilled help when necessary from your extension agent, beef specialist, range specialist or agricultural consultant.

Effects of drought on range plants and management

Drought or fire is a serious obstacle to successful range livestock management. Producers must understand how these impacts affect plants, grazing animals and livestock management, and what options exist. Forage production is decreased dramatically, but on range in good or excellent ecological condition, reductions are less dramatic. The ability of perennial plants to recover after drought is closely related to vigor before and during the drought. Fire is like overuse all at once, and recovery can be rather fast. Drought, if it is prolonged, can deplete root reserves and inhibit root growth.

Excessive grazing (more than 60 percent of current year's growth) decreases the ability of some plants to recover. Moderate use (25 - 55 percent) does not seem to affect the recovery rate. A drought or fire may require that livestock numbers be reduced according to forage supply. Retaining a rotational grazing system during these impacts is recommended over continuous grazing because periodic rest helps plants maintain vigor. Concentrating more animals into a single herd is recommended over having several smaller herds because by having more animals in a pasture, the entire pasture will be grazed more uniformly, and more use will be made of less-preferred plants. Other options include grazing crested wheat grass earlier and longer than normal, because it is one of the plants most tolerant of grazing.

Another option is keeping cattle on irrigated or sub-irrigated sites longer than usual. Fertilizer could be used to increase forage production on many of these sites. However, fertilizer is a cash cost, and soils should be tested before fertilizer is applied. Fertilizer needs moisture to be available to the plant, and in times of extreme drought this may not happen.

Initial questions

The producers who survive best during drought or after a fire are those who adopt sound management and financial plans and review them regularly. They make firm decisions and act quickly and early. Keep alert for opportunities such as leasing land instead of buying feed. Four factors which affect risk management include: 1) the total population of cattle in relation to feed availability, 2) how widespread the drought or fire area is, 3) the time of year and the likelihood of rain and reestablishment of adequate feed supplies in the area and, 4) evaluation of cash flow needs. Borrowing your way through a drought to maintain traditional herd size may inhibit long-term profitability. Borrowing may be a viable option after a fire.

Questions to answer when facing a situation of reduced forage supplies

- Are my animals losing weight or not performing adequately?
- What is the body condition score of my cows?
- Will I have to start to provide supplements?
- If the lack of forage continues, should I cull the least productive or "at risk" animals?
- What feeds are available to the ranch?
- Assuming I will have to purchase supplemental feeds, are they available, and at what cost?
- Is one option to sell hay and buy back grain for limit feeding?
- Do I have the feed resources to allow for full feeding vs. supplementary feeding only vs. limit feeding of grain?

Several options to consider include

- Doing nothing.
- Selectively reducing of the cow herd, especially the least productive cows.
- Weaning calves early to reduce nutritional demands on cows.
- Leasing additional grazing ground vs. purchasing supplemental feeds.
- Purchasing supplemental feedstuffs.
- Moving the cow herd to a dry lot for full feeding.
- Limit feeding grain to meet nutrient requirements.
- Selling all the livestock.

Keep the following in mind with regard to cow management

- Fertility of cows may decline when body condition score (BSC) drops below a 4, especially at time of calving and when they go into breeding season in poor condition. Without sufficient nutrients, particularly energy, cows lose considerable weight. When such weight losses occur, milk production decreases and reproductive activity may cease. The end result is light-weight calves and open cows. To prevent such undesirable effects, cows either must be provided sufficient nutrients to avoid weight loss and maintain production requirements or they must be relieved totally or partially from body stresses.
- Early weaning of calves is one option that allows cows to rebuild body reserves and rebreed the next year.
- Money and diminishing feed reserves are too valuable to waste on cows that are unproductive, not pregnant or are unsound. These animals are candidates for culling at any time and especially during drought conditions.

Considerations for water during a drought or after a wildfire

Water requirements of cattle may double during hot weather. If cattle don't have enough water, they may refuse to eat, experience lower production and become sick. Table 1 provides estimates of water consumption for cattle.

In some areas, you may be able to develop a spring or seep (a flow of ½ gallon per minute amounts to 720 gallons per day). Consider the possibility of installing a larger storage tank and piping water to troughs. You may need to install high-pressure plastic pipe to carry water from a central source. Although expensive initially, pipelines will prove useful for many years. Hauling stock water is expensive. However, it may be a viable strategy in some situations.

One concern about cattle drinking stagnant pond water during hot, dry weather is that animals can die if the water contains certain species of blue- green algae. Toxic blue green algae blooms occur on or near the

TABLE 1. Estimated water consumption by different classes of beef

Class of cattle	Water consumption at 88°F, gallons/day
Cows	
Dry	14
Lactating	17
Bulls	18
Growing cattle	
400 lbs	9
600 lbs	12
800 lbs	14
Finishing cattle	
600 lbs	14
800 lbs	17
1000 lbs	20
1200 lbs	23

water surface under conditions including hot, sunny days and warm, nutrient-rich water. Poisoning by the algae is characterized by convulsions, bloody diarrhea, and sudden death. Clinical signs in blue green algae poisoning include nervous derangement, staggering, tremors, and severe abdominal pain. Affected animals rarely range far from the water source.

Toxic blooms of algae are unpredictable. Not all blue green algae are poisonous, and the blue green algae that can generate poisonous toxins don't always do so. Presence of potentially-poisonous blue green algae may be determined by microscopic examination, but the presence of algae does not mean the water is toxic. If you suspect blue green algae, contact your veterinarian or county agent to determine which samples would be appropriate for your situation. If concentrations of blue green algae are suspected, walk around to the windy side of the water body. If any dead animals such as mice, muskrats, birds, snakes or fish are present, assume a poisonous condition exists.

Supplementing cattle on affected pastures and ranges.

Producers generally have two options for meeting the nutrient requirements of cattle on burnt-over or drought-affected pastures and ranges. The first is to provide supplemental feed to ensure the herd has adequate energy, protein, vitamins and minerals. The second is to reduce the nutrient requirements of the cow to a point where they can be met with available forage.

Drought-affected or burned pastures and native range generally do not produce adequate forage to maintain normal stocking rates, so producers must provide supplemental energy to meet the needs of the herd. If forage is plentiful, protein often is the choice of a supplement.

If you supplement hay on range- land, try not to buy or harvest weed-infested hay. The future cost of feeding weed-infested hay far outweighs its feed value in the short-run. If weedy hay must be fed, feed in an area or holding pasture that is removed from streams, riparian areas and wooded areas. Be sure to keep cattle confined for several days after feeding the weedy hay to prevent them from spreading viable seed from their digestive tract. Observe holding pastures and feeding areas closely, and treat weed infestations.

Try to take advantage of areas dominated with annual species. They should be grazed early in the season when nutrient value is high. This will allow grazing deferment on higher-condition range dominated with perennial plants.

Available crop residues such as small grain straws and other byproducts of crop production can stretch tight feed supplies during drought conditions.

Pastures and native range that are dormant due to drought conditions may be low in vitamin A, phosphorus and protein. Meeting the need for these nutrients is important in maintaining herd productivity.

Reductions in stocking rate will reduce stress on range plants and provide more forage for remaining cattle. When stocking rates are reduced in accordance with production, lesser effects on weaning weight may occur. If stocking rate is not reduced, supplemental feeding is necessary to maintain herd productivity and alleviate grazing pressure.

Two Options

When pasture is spare and poor quality If only slightly limited, the feeding of range cubes (minimum 20% crude protein) or mixtures of grain and cottonseed or soybean meal at rates of 3 to 5 pounds per cow daily may work for a while. Cubes with a more natural protein and less crude fiber (less than 10%) are better.

When pasture becomes extremely short, consider purchasing hay or replacing feed for the pasture as well as selling stock. Remember that most grass hay has only 50 - 65% of the energy content of grain so that one pound of grain can replace 1.5 - 2.0 pounds of hay. A pound of grain will only replace 1.2 - 1.4 pounds of alfalfa hay. It doesn't make sense to pay $105 per ton for poor quality grass hay when grain would cost very little more. It is necessary to start cows on grain slowly and feed it so that all cows have opportunity for their share of the feed. It is possible to feed up to 80% grain in a maintenance diet for British-bred cows. Grain-based supplements should be fed daily to reduce the risk of acidosis. All cattle need some forage in the diet to minimize digestive problems.

General recommendations

Minerals

Provide the same salt and mineral mixture during drought or after wildfire as you would during normal conditions. However, during drought, phosphorus supplementation is even more critical. A complete mineral supplement containing 12 percent calcium, 12 percent phosphorus, 5 percent magnesium, 0.4 percent zinc (4000 ppm), and 0.2 percent copper (2000 ppm) has worked well in many areas.

Vitamin A

Lack of vitamin A may become a problem during the fall and winter for cows that grazed drought-affected pastures during the summer. Vitamin A is lacking in forages that grow under drought conditions and hay produced from drought-affected forages. Cows should receive vitamin A and D booster shots approximately 30 days prior to calving if they have not been previously supplemented with vitamins.

Protein

Pastures dormant due to drought conditions are usually deficient in protein. If these conditions occur during the breeding season, reductions in pregnancy rate can occur. Provide dry cows with approximately 0.5 - 0.75 pounds of supplemental crude protein and lactating cows with 0.9 - 1.2 pounds of supplemental crude protein per day. This can be fed as approximately 1.0 - 1.5 pounds of soybean meal for dry cows and 2.0 - 2.5 pounds of soybean meal for lactating cows. Feed 1 to 2 pounds per day of a high protein supplement to dry cows and as much as 2 to 3 pounds to lactating cows to maintain forage intake and efficient utilization of forage.

You may need to supplement protein for optimum breeding rates. Protein-based supplements (cottonseed meal, soybean meal and canola meal), commercial protein blocks, liquids and tubs would also be appropriate. Alfalfa hay, sunflower meal, safflower meal and other protein meals may also be used as protein supplements.

Energy

During drought conditions, energy may be the most limiting nutrient for grazing cattle. Several options are available for supplying energy to cattle on drought-stressed pasture. Hay, grain and crop processing byproducts can all be used to supply energy to grazing cattle. Low-quality forages can also be ammoniated to increase digestibility and protein content.

Supplementing grain on pasture can result in a “Catch 22” problem. Too much supplemental grain can reduce forage intake and digestibility, resulting in less energy available to the animal from available forage. The reduction in forage intake may not be undesirable during a drought. As a general rule of thumb, up to 0.2 percent of body weight of supplemental grain per head per day will not result in large decreases in forage intake and digestion. For example, a 1,200-pound cow could receive 2.4 pounds of grain per day without drastically reducing forage utilization. For some grains, processing may be necessary for optimum use by cattle. Corn and oats can be fed whole but may be utilized better if coarsely rolled before feeding. However, barley and wheat should be coarsely rolled. Avoid fine grinding and rolling, which results in fines and dust. These can result in increased incidence of acidosis and founder. In addition, dusty supplements are unpalatable.

The producer must weigh the additional costs of processing vs. value of the grain. Grain processing coproducts such as wheat midds, soybean hulls and corn gluten feed, which contain highly digestible fiber, provide energy while alleviating much of the negative impact that grain supplementation has on fiber digestibility. These byproducts also provide protein, which may be limited in drought-stressed forages. When using byproduct feedstuffs, make sure that the mineral program is balanced. These feeds are typically high in phosphorous and potentially high in sulfur, which may lead to mineral imbalances. The trace mineral levels may be somewhat low as well.

If pasture conditions are extremely poor, producers may consider feeding cows in drylot. This may be more cost effective than supplementation on range if large amounts of supplement must be transported and fed to cows daily. In addition, it may allow pastures a much-needed rest period to begin recovering from drought or wildfire.

Reducing nutrient requirements of the cow herd

Lactation represents the greatest nutrient demand for cows during a yearlong production cycle. It increases demand for energy, protein, water and other nutrients. One of the simplest ways to reduce nutrient requirements is to wean the calf. This practice can cut nutrient requirements by one-third to one-half depending on milk production of the cow. Early weaned calves can achieve adequate rates of growth if given access to a high-quality ration. Dry cows will eat less forage and usually travel further distances for forages than lactating cows, further reducing demand on the pasture. By removing the demands of lactation, acceptable pregnancy rates and calving season length can usually be maintained.

Producers may consider weaning only a portion of the herd early. In this case, logical candidates for early weaning are cows nursing their first and second calves. These animals have nutrient requirements for growth in addition to maintenance and lactation. The nutrient requirements for lactation and growth are given higher priority than the need to reproduce. By removing the demands of lactation on nutrient requirements, growth and reproduction will receive a greater proportion of the nutrients available.

Unavailability of feeds or unusually high cost often prohibits feeding lactating cows the nutrients necessary for lactation and rebreeding. Mature cows need nutrients for body maintenance, lactation and rebreeding. First-calf heifers and young cows must have additional nutrients for growth. To reduce stress and lessen the total feed necessary, the only production requirement that can be removed is lactation. Lactation stress may be removed from cows or heifers by weaning calves after 60 to 80 days of age, or partially removed by creep feeding.

Feeding management options

- Design a feeding program to get the most mileage from available feeds on your ranch or in your area.
- Supplement low quality feeds correctly. Your Extension agent or nutrition consultant can help determine if you are meeting cow and calf nutrient requirements.
- Underfeeding nutrients lowers production. Overfeeding nutrients increases feed expense and reduces the net return over feed expense.
- Make every effort to reduce feed waste.
- Feed the highest quality feeds to animals that have the highest nutrient requirements, (replacement heifers, growing calves, lactating cows).
- Feed the lowest quality feeds to cows in the middle-stage of pregnancy.
- Save the better-quality feeds for those periods just before and after calving.
- Consider substituting grains for hay when these substitutions can balance the ration more adequately at a lower price (see section on substituting grain for hay).
- Consider ammoniating crop residues such as wheat and barley straw to improve digestibility and intake.

Stay alert for potential problems

- The use of salt to limit supplement intake may increase water intake 50 to 75 percent. Water must not be limited in any way or salt toxicity may result.
- Overconsumption of urea-containing supplements by cattle on forage-scarce ranges may result in ammonia toxicity. Generally, cattle performance on urea-type supplements can be lower than expected when energy or forage is in short supply.
- Hay cut under moisture-stressed conditions, especially grain-type hays, may contain high levels of nitrate. It is recommended to test for nitrate before feeding such hays, especially before feeding large amounts. Be sure to take a good representative sample for analysis.
- Prussic acid or cyanide poisoning can also be a problem in grazing drought-stunted plants such as sorghum, sorghum hybrids and sudan grass. If forage for hay is allowed to sun-cure thoroughly for three to five days, bleaching out any bright green color, prussic acid problems should be lessened.
- Cattle grazing short pasture are more likely to consume poisonous plants. Poisonous plants may grow faster after wildfire.
- Infrequent feeding (from alternate day to once per week feeding) of protein supplements (less than 30 percent crude protein) like oil-seed meal cubes, has been recommended to save labor. The practice is still good for high protein supplements but is not to be used for grain-type supplements. High-energy supplements (grain, breeder cubes, etc.) should be fed daily, especially where ≥0.5 percent of body weight may be fed daily. High-energy acid-producing feeds tend to decrease rumen pH and fiber digestion and alternate day feeding of large amounts magnifies the decrease in rumen pH.

Ammoniated straw

Ammoniated straw may be an option. Ammoniation of straw with 60 pounds of anhydrous ammonia per ton of straw will increase cattle performance and make it possible to utilize wheat straw as the only roughage in the diet, something not recommended for untreated straw. A summary of four trials is presented in Table 2, indicating that actual daily gain was improved by 0.31 to 0.82 pounds daily.

TABLE 2. Summary of results using ammoniated wheat straw

Source	Cattle type	Untreated	Treated	Daily gain, lbs response
Oklahoma	Yearlings	0.60	1.25	+0.65
Oklahoma	Open cows	0.09	0.40	+0.31
Nebraska	Preg. Cows	0.26	0.88	+0.62
Purdue	Preg. Cows	-1.00	-0.18	+0.82

Increased digestibility and intake were the cause of the improved gain. Two to three pounds of supplement or alfalfa hay were fed along with free choice ammoniated wheat straw. Ammoniation alone does not make wheat straw a complete feed. A good mineral/vitamin supplement is essential and 1 to 2 pounds of natural protein is needed along with the non-protein nitrogen added by ammoniation. Toxicity problems, involving calf losses and wild irrational cattle behavior, have been reported when ammoniating high-quality forages. Toxicity problems have not been observed with ammoniation of wheat straw or similar products.

Unadapted cows should be started on grain feeding slowly or the problems of acidosis, founder and even death may result.

- Rumen impaction may result where cattle receive inadequate protein (less than 7 percent to 8 percent CP in total diet) and too much of a low quality/ high fiber forage such as drought affected pasture or wheat straw only. Lack of adequate water will aggravate the impaction problem.
- Hardware disease. Hay harvested from vacant city lots, roadsides etc., may contain nails, wire or foreign objects which can pierce the rumen wall resulting in death of the animal. Close observation of feeds and the use of magnets in grinder/mixers can help to reduce the potential consumption of problem materials by animals.

Sources

The sources of information for this section are: Montana State University, North Dakota State University, Texas A&M University, Penn State University, Queensland Beef Industry Institute, and NSW Agriculture.

Water Quality Concerns After Wildfire

Gene Surber, *former Extension Natural Resources Specialist, Department of Animal and Range Sciences, Montana State University*
Updated by Adam Sigler, *Associate Extension Water Quality Specialist, Department of Land and Environmental Sciences, Montana State University (August 2017)*

Wildfires not only impact vegetation and land animals (including human beings and their property) they can also trigger flooding and harm aquatic habitat and water quality. The increased probability of catastrophic wildfires in the western United States and elsewhere in the world has increased the need to understand the effects fires may have on the physical and chemical properties of water. Surface water flowing from burned areas may carry greater levels of sediment, organic debris and chemicals that may significantly degrade water quality and impair aquatic habitats.

Water quality, be it surface or subsurface water, is generally evaluated according to three major criteria: microbiological, physical and chemical properties. Within each, individual items relate to safety and aesthetics. Feeding poor quality water can have an effect on livestock. Often animals may not exhibit the effect even though productivity has been reduced.

Water quantity is also important. Providing unlimited high-quality water is necessary for optimizing animal health and production. Water constitutes 60 to 70 percent of an animal's body. Consumption of water is more important than the consumption of food nutrients. Animals should be given all the water they can drink. Animals deprived of a sufficient water supply may become stressed and dehydrated. Water-related health problems in livestock may be caused by lack of an adequate supply and/or a supply of poor quality water. A general guide is that animals will drink 6 to 12 percent of their body weight in water per day, lower levels in cooler climates and the higher level for hotter climates. Considering that a gallon of water weighs 8.3 pounds, a 1200-pound cow needs 8.7 gallons per day in January and during the hot season she needs 17.4 gallons per day.

Water consumption requirements vary depending on such things as kind and size of animal, physiological state of the animal (lactating, pregnant, growing, maintenance), activity level, type of diet, climatic conditions, and quality of the water. Lactating beef cows will consume up to 75 percent more water than dry cows. Calves require much more water after weaning than before. More active animals require more water. Activities such as grazing, and breeding may increase the evaporative heat loss of the animal, dramatically affecting water needs. Dry diets require more water consumption than moist diets such as silage or lush pasture. Hot summer days (90°F or 32°C) will result in 2.5 to 3 times the water consumption of fall, winter and spring days when temperatures are 32°F (0°C) and below. Humidity also affects the amount of water animals will consume by increasing their demand. Higher humidity limits the cooling ability of animals, through evaporespiration. Water with a higher salt content can actually increase the animal's water consumption.

General Impact of Wildfires

Fires change rainfall interception, infiltration, evapotranspiration and snow accumulation through the loss of vegetation canopies, litter and soil organic matter. This greatly increases erosion from rainfall. Changes in these processes can result in a large net change in runoff and erosion on the watershed scale. For high severity wildfires, peak streamflow discharge can be up to 60 times higher than what would be expected under pre-fire conditions or from comparable unburned watersheds.

During the fire itself, rapid and extreme increases in water temperatures, lower water levels, and soil and ash polluting the water may make it impossible for fish to breath.

The loss of vegetation and the increase in water flowing through the watershed also affect the movement of nutrients. Following wildfire, nutrient losses from a watershed usually increase. Nutrient concentrations including nitrate, organic nitrogen, potassium, calcium and magnesium commonly increase after fire. The type and amount of specific nutrients lost following fire vary from watershed to watershed, depending on burn intensity and erosion rates. Increased concentrations of nutrients into water bodies are short-lived, generally being greatest during the first few storms or snow melts after the fire. Water quality typically returns to pre-burn levels within one or two years, as fresh water entering the streams from springs and the atmosphere over time helps clean and dilute most pollution.

Soil and water quality

Physical and chemical properties of forest soils, which determine site productivity and influence water infiltration and runoff rates can be significantly changed for a few years following wildfires. Changes in soil pore space and infiltration rates are small as long as the organic layer is not completely consumed. A properly applied prescribed fire will not burn all of the litter layer, nor will it kill the roots of understory plants, whereas wildfires usually burn hot enough to completely consume all organic or litter layers and also kill roots of understory plants. Without litter and plants to protect the soil, runoff and erosion can create changes to water quality and quantity.

Physical water quality conditions

Many physical water quality conditions in streams can be affected by wildfires. Surface water temperature, turbidity, sediment, and algae will be discussed.

Temperature

Since more sunlight reaches streams and the soil along their banks, water temperatures may increase after a wildfire. Soil properties can be altered when the loss of litter and duff layers causes soil to be heated. This can form a water repellent layer of soil. The actual rise in temperature depends on both the length of stream exposed and the mitigating effects of increased stream flow.

Elevated stream temperatures may affect fish habitat. However, in normally cool streams the increase may not be enough to cause problems. For optimal livestock production water should be neither hot nor frozen. Steers gained .3 to .4 lbs. more per day when drinking water between 40 and 65 degrees F versus those drinking warmer water.

Sediment and Turbidity

Wildfires remove plants whose roots hold the soil together, so after a fire even a mild rain can cause erosion. Eroded soil is carried into rivers and lakes. This sediment can take the form of suspended and/or bedload sediment. Suspended sediment is typically fine particles and organic material that stays mixed in the water. Bedload is material that is too heavy to stay suspended in the water and moves in contact with the streambed or as a result from storms or human-induced events.

Turbidity is cloudiness in water caused by suspended particles. High levels of turbidity can make treatment and filtering of water difficult. Turbidity may also affect the palatability of the water for livestock use, and the animals' acceptance of the water.

Algae

Algae is a general term used to describe many forms of aquatic plant life, but not all aquatic plants are algae. Nearly all waters have some form of algae growing in them. Nutrients and sunlight are needed along with the

TABLE 1. A guide to the use of saline waters for livestock

Total Soluble Salts Content of Waters (mg/l)	Comments
Less than 1,000	These waters have a relatively low level of salinity and should present no serious effect.
1,000 to 2,999	Waters should be satisfactory. May cause temporary and mild diarrhea in livestock not accustomed to them, but should not affect their health or performance.
3,000 to 4,999	Should be satisfactory, although may cause temporary diarrhea or be refused at first by animals not accustomed.
5,000 to 6,999	Can be used with reasonable safety. Avoid using waters approaching the higher levels for pregnant or lactating animals.
7,000 to 10,000	Considerable risk may exist using these waters for pregnant or lactating animals, young animals or any animals subjected to heavy heat stress or water loss. In general, use should be avoided although mature animals may subsist for long periods of time under conditions of low stress.
More than 10,000	Not recommended for use under any conditions.

From NAS, 1994. Nutrients and Toxic Substances for Livestock and Poultry.

water to create growth conditions for algae. Increased water temperature and nutrients following wildfires, especially where the canopy cover of a stream has been removed, will greatly increase algae growth in surface waters. Blue-Green Algae can be toxic to animals. However, only a couple toxic types have been found in Montana and they usually occur in still waters. No good method exists to predict whether or not the algae will produce the toxins. If you suspect algae toxicity, look for any dead animals around the water source, as nearly all animals are affected. Blue Green Algae is also slimy and difficult to pick up in your hand. So, if you can pick up the algae, it is probably not a toxic form.

Chemical water quality conditions

pH

The pH of water denotes either alkalinity or acidity. A pH of 7 is neutral; over 7 indicates alkalinity; below 7 indicates acidity. Forested lands are normally acidic (less than pH 7) while many grasslands are alkaline. Most cases of increased pH after wildfires are associated with forested land where soil pH is typically acidic and large amounts of organic matter burn. It is rarely a concern, as most water samples fall within the acceptable range of 6.5 to 8.5.

Alkalinity

Increased alkalinity is usually attributed to ash in a stream. Bicarbonates and carbonates may contribute heavily to alkalinity (pH) levels. As the pH goes up, the waters become more alkaline, and at values of around 10, waters are very highly alkaline and contain carbonates. Excessive alkalinity (above 8.5) in water can cause physiological and digestive upset in livestock. However, most waters have alkalinities of less than 10 and are not harmful.

Salinity

Saline water is not the same as alkaline water. The expression "Total Dissolved Solids" (TDS) is often used to denote the level of water salinity. Salinity refers to salts dissolved in water. Salts commonly present in water include carbonate, bicarbonates, sulfates, calcium, magnesium, nitrates, chlorides, phosphates, and fluorides. Highly mineralized waters (high TDS) don't have much effect on health as long as there are no continuing laxative effects and normal amounts of water are consumed. One gram of sulfate per liter may cause scours. Salts such as sodium-chloride change the electrolyte balance and intracellular pressure in the body, producing a form of dehydration. Salts also place a strain on the kidneys. Excess fluoride causes degeneration of the teeth. Occasionally the levels of salts are high enough to cause harmful effects that result in poor performance, illness or even death in animals forced to drink them. Various salts have slightly different effects. These effects seem to be additive, which means that a mixture of them causes the same degree of harm as a single salt of the same total concentration.

Animals have the ability to adapt to saline water quite well, but abrupt changes from waters of low salts to waters of high salt concentrations may cause harm. Animals may refuse to drink high saline water for many days, followed by a period where they drink a large amount. They may then become sick or die. High salt concentrations that are less than toxic may

TABLE 2. Nitrate levels as ppm in water and percent in forages expressed in three different units

Potassium Nitrate (KNO_3)	Nitrate Nitrogen ($N\text{-}NO_3$)	Nitrate (NO_3)	Interpretation
Water, ppm			
0-720	0-100	0-440	Considered safe
720-2100	100-300	440-1300	Exercise caution. Consider additive effect with nitrates in feed.
>2100	>300	>1300	Potentially toxic
Forages, %			
0-1	0-0.15	0-0.65	Considered safe
1-3	0.15-0.45	0.65-2	Exercise caution. May need to dilute or limit feed forages.
>3	>0.45	>2	Potentially toxic

1% KNO_3 = 0.14% N = 0.61% NO_3 1% N = 7.22% KNO_3 = 4.43% NO_3 1% NO_3 = 0.23% N = 1.63% KNO_3

actually cause an increase in water consumption. The tolerance of animals to salts in water depends on factors such as water requirements, species, age, physiological condition, season of the year and salt content of the total diet as well as the water.

Salinity is expressed as parts per million (ppm) or as milligrams per liter (mg/l). Electrical Conductivity (EC) is directly correlated to TDS and can also be used as a measure of salinity.

Nutrients

Nitrate and phosphorus in surface waters, which contribute to increased aquatic plant and algae growth, increase following a wildfire.

Nitrogen

Nitrates, mainly nitrate-nitrogen, increase in the soil and are mobile in water. Therefore, they readily move into ground and surface water. The nitrates are not very toxic themselves, but in the rumen the bacteria reduce them to nitrites that then get into the blood stream. Nitrites convert the red pigment, hemoglobin (which is responsible for carrying oxygen from the lungs to the tissues) to a dark brown pigment, methemoglobin, which will not carry oxygen. When this conversion is about 50 percent complete the animal shows signs of distress suggesting a shortage of breath. At an 80 percent or more conversion, the animal usually dies from suffocation. Non-ruminants may convert small amounts of ingested nitrate to nitrite in their intestines, but the amount converted is not harmful.

Nitrates in the diet may interfere in the conversion of carotene to vitamin A under some circumstances, but experimental data shows this to be of no practical significance. Further, the experimental evidence suggests that chronic nitrate poisoning does not occur in livestock and that the young are no more susceptible to the acute type than are older animals. As a rule, nitrate poisoning results from ruminants eating forages of high nitrate content. Nitrates are occasionally found at toxic levels in water. Nitrites are also found in water on many occasions, but not at levels dangerous to livestock. As a rule, reports of water analyses include nitrites with the nitrates.

TABLE 3. Contaminant levels generally considered safe

Element	ppm
Aluminum	5.0
Arsenic	1.0
Boron	5.0
Cadmium	0.05
Chromium	1.0
Cobalt	1.0
Copper	0.5
Fluoride	2.0
Lead	0.1
Mercury	0.001
Nickel	1.0
Selenium	0.1
Sulfate	1000.0
Vanadium	0.01
Zinc	25.0

Phosphorus

Phosphorus will usually increase the first year after the fire. Phosphorus readily binds to soil particles. Because of this adherence to sediments, initial storms following a fire wash increased levels of phosphorus into surface waters. An increased phosphorus level in water contributes to eutrophication, a process of nutrient enrichment that results in the body of water becoming filled with aquatic plants and low in oxygen content.

Dissolved Oxygen

Some types of aquatic life can survive in streams with a Dissolved Oxygen (DO) level of 4-6 mg/l. However, to maintain cold water fisheries DO levels must be between 8 and 13 mg/l. Dissolved Oxygen levels are lowered when sediments and debris enter the water. The sediments absorb sunlight, increasing the temperature of the water. This lowers the water's oxygen holding capacity. Cold water will hold more oxygen than warm water. Soil temperatures that increase as a result of wildfires also increase the water temperature. The decomposition process of organic matter in the water lowers the DO content because decomposition uses oxygen.

Other Chemicals

Many other chemicals may be found in water, some of which could be detrimental to livestock production, but are not considered to be of major concern after wildfire, unless special situations existed in the area of the fire. Table 3 lists what are generally considered safe levels of some potentially toxic nutrients and contaminants in water for cattle.5

Summary

Wildfires can have an effect on water quality. Most effects come from added sediments and debris to the surface water. In some cases, these physical effects can reroute streams where other chemical and biological conditions can be concerns for animals drinking water and aquatic life. If a water body is known to have nutrient levels that are high enough to be given consideration prior to the wildfire, special care should be taken to manage for any increases resulting from the fire.

References

- Boyles, S. 2000. *Livestock and Water.* Beef Infobase, version 1. The ADDS Center.
- Boyles, S. L., Kurt Wohlgemuth, George Fisher, Darnell Lundstrom, Ladon Johnson. 1988. *Livestock and Water.* North Dakota State University, Extension Service Bulletin #AS-954.
- Chandler, Craig, Phillip Cheney, Philip Thomas, Louis Trabaud, and Dave Williams. 1983. *Fire in forestry, Volume I: Forest fire behavior and effects.* John Wiley & Sons, New York.

Tree and Forest Restoration Following Wildfire

Peter F. Kolb, *Extension Forestry Specialist, Montana State University and School of Forestry, University of Montana*
(Updated August 2017)

After a wildfire has run across a landscape, it often appears as if the flames have destroyed all vegetation. However, many of our native trees, shrubs, forbs and grasses have some mechanism of coping with fire. Some will grow new leaves or needles; others will re-sprout from their roots, while others have fire-resistant seeds that will sprout following a fire. Much of the response will depend on the intensity and duration of the fire. Fast moving fires such as those that occur on grasslands usually scorch leaves from trees but do not kill the woody stems or root systems. On the opposite side of the spectrum, fires that occur where heavy woody fuels have built up tend to burn for a longer duration around tree bases, releasing intense and direct heat that, in essence, cooks tree stems and root systems. Under the latter conditions the damage that fire causes to trees and shrubs can be more severe even though the tree may look as if it sustained less damage.

A secondary wildfire effect results from blackened surfaces absorbing more of the sun's energy. This causes severe increases of soil surface temperatures and plant stems, and may kill plants that had survived the initial fire. The following paragraphs will summarize some of the things that can be done to help trees and shrubs recover after a wildfire.

Assessing trees

Although the temptation following a wildfire is to remove every blackened tree, it is important to first assess actual damage. Trees that look burned and have leaves or needles scorched are not necessarily dead. Fire usually kills trees in two ways: by killing the cambium layer just under the bark of a tree, and by killing all of the leaves and buds. Often some of the cambium and some of the leaves have been burned, but not enough to kill the tree. How much damage was done will depend on how the fire behaved and what tree species burned. In most cases, if salvage logging is not being considered, it is best to wait until the following spring to determine if new leaves and needles reappear before deciding whether or not to cut down a scorched tree. If new leaves appear, the tree will survive and often will fill out to its former glory in 1 to 3 years. If no new needles or leaves appear by June, the tree is most likely dead.

There are several ways of assessing trees after a wildfire has damaged them. The first is to determine the extent of damage to the live needles on the crown of the tree. Needles that are intact but have turned orange or brown are referred to as "scorched." Needles that have been burned are referred to as "consumed" (Figure 1). Of all the conifers across Montana, two tree species, ponderosa

FIGURE 1.

Zero scorch — 50% scorch: Most ponderosa pine, larch, and Douglas fir will survive up to 50% crown scorch. Spruce, grand and subalpine fir, and lodgepole pine may have severe damage.

90% scorch — 100% scorch: Ponderosa pine and larch with 9" or larger diameter stems may survive.

Crown consumed: Few ponderosa pine and larch survive.

pine and western larch, are the only species that can recover from a severely scorched crown. Ponderosa pine and Larch that have had over 90 percent of their needles scorched occasionally recover. Douglas-fir has an intermediate resistance, and may survive up to 50 percent crown scorch. The other common native tree species (lodge-pole pine, grand fir, subalpine fir, hemlock, cedar and spruce) are often killed if their crowns are scorched more than 30 percent. If the needles in the crown have been completely consumed it is highly unlikely that any tree species will survive.

Heat-related injury to the tree's cambium layer is as important as foliar damage. This is the part of the tree that adds woody growth to the stem every year and is found just underneath the tree's bark. Some tree species have evolved a thick bark to insulate this layer. Ponderosa pine and western larch that have stem diameters greater than 9 inches are often characterized by bark that is 1 to 3 inches thick with a heat-resistant, plate-like structure. Older Douglas-fir can also have heat-resistant bark, and are distinguishable from ponderosa pine and larch by bark that does not flake apart as easily. All of the other native conifers have a much thinner bark that is not fire resistant.

To assess a tree shortly after a fire, peel back the bark on twigs and the stem in a few strategic areas. Make quarter-sized or smaller cuts in the bark to determine if the cambium area has been killed. If the cambium under the scorched area is white or green and juicy-slimy looking, the stem has survived the fire and the tree has a good chance of re-sprouting leaves or needles. If the inner bark that lies next to the wood is dark brown, streaked and/or dried out, the stem area you are examining is probably dead. Fire-resistant trees like ponderosa pine can have a portion of their cambium killed and still survive a fire. If the fire has killed more than 75 percent of the stem circumference, the tree will probably not survive to become a healthy tree.

Although stem assessments and percentage scorch are the best tools for assessing tree health, another assessment that can be made is to check for intact buds at the ends of branches. Buds that are still green and moist inside are alive, and if the tree stem has survived the fire, the tree has a good chance of recovering. Be sure to check several branches and the main stem of the tree. Depending on the intensity of the fire, small twigs may be killed but larger branches left alive, or if there was a lot of fuel around the base of the tree, the stem adjacent to the ground may have been killed while the branches still look alive. It is important to check the entire tree (base of the main stem, cambium, larger branches and smaller twigs) to determine the extent of the damage. Or, wait until next spring for new leaves to form. (Figure 2).

Assessing soils

Wildfires usually travel quite rapidly over the surface of soil. As the fire approaches, the intense radiated heat preceding the flames usually vaporizes a lot of the naturally occurring terpenes, resins and waxes that plants produce to protect their stems and needles. Although many of these vapors burn off, some condense on the cooler soil surface and form a water-resistant layer. (These same substances are captured by wood processing plants and become major ingredients in the wood preservatives people apply to their decks.) Typically, the greater the intensity of a fire, the more gases condense on the soil surface and the more impermeable the soil surface will become to water. This results in what are called hydrophobic soils, which can significantly decrease the recovery of plant species on burned areas by excluding water recharge to the soil and promoting serious erosion.

Often hydrophobic soil conditions are only present in the upper ½ to 2 inches of soil and in patches across the burned area. On lightly burned areas where soil surface organic matter did not completely burn, hydrophobic conditions usually don't persist very long. (Figure 3, page 16). On sites where soil surface organic matter completely burned and mineral soil particles were baked, hydrophobic conditions can last up to a year. These areas are often identifiable by a layer of powdery white ash and orange colored soils. When possible, the latter conditions can be amended by lightly scarifying soil surfaces.

FIGURE 2.

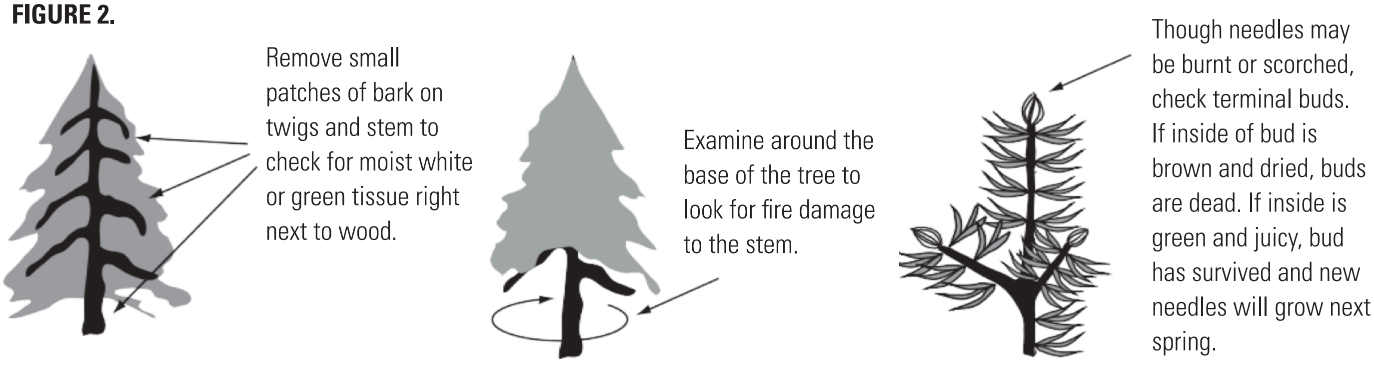
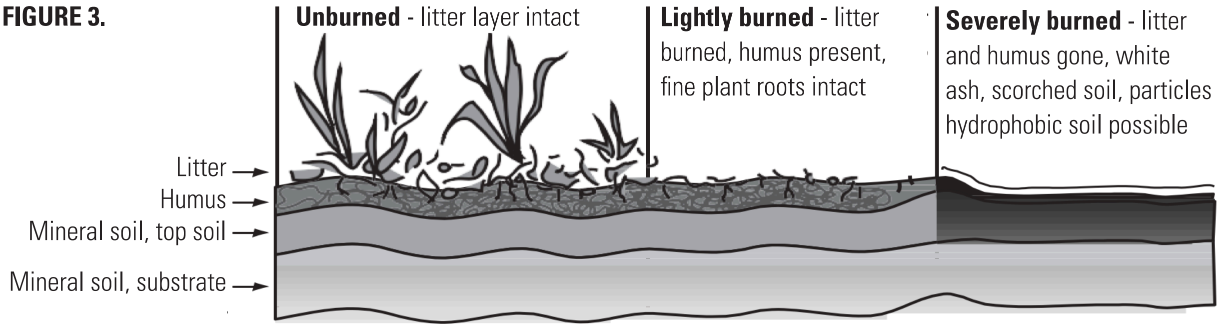


FIGURE 3.



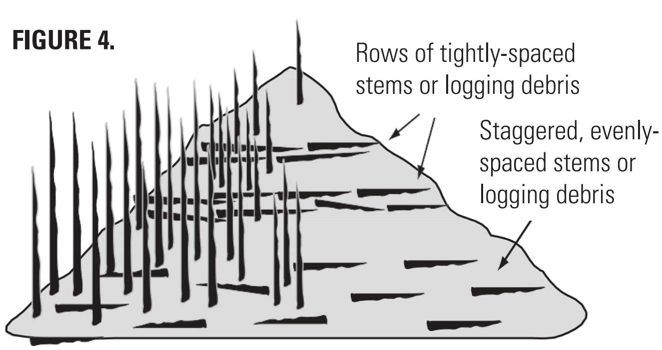
This can be accomplished by dragging a shallow chisel implement over the area that does not penetrate the soil any deeper than 1 to 2 inches. Deeper penetration can result in serious tree root injury. Mulching scarified or hydrophobic areas will further help increase water absorption and reduce surface erosion.

Soil surface amendments

The black surface left by a fire absorbs almost all of the sun's energy, resulting in high soil temperatures, which can cause the soil to dry out more rapidly than normal. Both the increased temperature and dry soil conditions can harm the root systems of surviving trees. (An exception to this may be quaking aspen and cottonwood – warmer soil temperatures can stimulate root suckering if the mature trees have been killed). Since vigorous roots are required for a tree to recover from needle or leaf scorch, it is important to protect them. Soil temperatures can be kept cool by mulching lightly with straw around the bases of trees. The mulch should extend out from the tree stem 1.5 times as far as the longest branches. Straw mulch absorbs much less of the suns energy and keeps the soil cool and moist. Often, breaking up the black surface left by fire will also reduce excessive soil surface temperatures.

Applying grass seed to undisturbed burned soil surfaces often results in poor grass seedling survival. Black surfaces warm to lethal temperatures for grass seed when exposed to the sun and often do not retain enough moisture for good seed germination. If a site has been severely burned and has hydrophobic soil conditions, it is recommended to break up this type of surface condition. Shallow plowing, raking, or logging equipment operation can accomplish this. Note: this is the only circumstance where "heavy-handed" soil disturbance is recommended! On sites where the organic layer on the soil surface is intact, only light disturbance is recommended to enhance the surface roughness and allow for a better seedbed. Take care to avoid losing the remaining organic layer to erosion. Take care to match the grass species to be seeded with the ecology of the site. It is recommended that an application rate of 40 seed/ft^2 be calculated and used.

FIGURE 4.



Contour felling fire-killed trees has been shown universally to be the most effective tool for minimizing soil and ash surface erosion. The practice involves cutting down trees in a manner that lays them along the side of the hillside (Figure 4). Since a fallen tree stem normally only contacts the soil surface with 15 percent or less of its stem, it is also necessary to cut the entire lengths into approximately 4-foot sections. Often trenching soil on the uphill side and pounding stakes along the downhill side are necessary to stabilize logs. The greater the steepness of the slope, the more contour logs are needed. Another means of achieving the same objective is through contour orientation of logging debris from salvage logging.

Salvage logging: When and where is it appropriate?

Wildfires have been a natural component of inland northwestern U.S. ecosystems for at least 12,000 years. A theory that is gaining increased scientific support is that after such a time span, the plant, animal and fungal species of these ecosystems are adapted to and in cases, may be dependent on this type of disturbance. Therefore, wildfires are needed to maintain ecosystem processes, and the aftermath of wildfires (dead trees) will perform some function necessary for native ecosystems to be maintained. A fundamental question that arises is: "Are we doing harm by extracting wildfire killed trees?" To attempt to answer this question, the current status of forest ecosystems of the Inland Northwest needs to be addressed. Assessments and research indicate that a large proportion of our forests are more densely occupied by trees than occurred historically. Furthermore, the tree species distributions across these forests tend to be skewed heavily towards shade adapted and fire-intolerant trees. These phenomena are suggested to have occurred in part as a result of 90+ years of wildfire suppression activities. These data, when modeled using fire behavior models, indicate that the forest wildfires that occur across the Inland Northwest tend to burn more severely than historically, which can also mean that a larger proportion of dead trees result. The severity of the fires that occurred in 2000 supports these modeled results.

Wildfires can be categorized into three types of forest fire severity:

1. Crown fires, which consume mature standing live trees and release enough heat energy to consume even soil organic mats;
2. Lethal understory fires, which stay out of the tree crowns but release enough energy to kill most of the mature live standing trees and consume a large proportion of the soil organic mat; and
3. Surface fires, which consume smaller diameter fuels but leave mature live trees and most of the soil organic mat intact.

Of these three types of fire behavior, crown fires and lethal understory fires tend to kill enough mature trees to warrant an economically-feasible salvage logging operation.

Pros to salvage logging:

- Severe fires create enough ash to plug soil pores and thereby significantly reduce water infiltration rates. Snow-melt and rainstorms result in more water than the soil can rapidly absorb. A high probability of massive soil surface erosion and sediment deposits in streams results. Management practices that result in an increase of surface organic debris in close contact with the mineral soil underneath the ash layer can impede surface water runoff. This allows greater water absorption by the soil and reduces erosion. Contour felling of trees is one of the most effective restoration processes used to achieve this objective, but is labor intensive and expensive. Salvage logging can achieve the same objective if logging debris is used in the same way as contour felling.
- Ash layers create an environment that can be hostile to rapid recolonization by tree seedlings and other potentially desirable plant species. The black surface of burned areas can reach temperatures in excess of 170°F, which is lethal for many plant species. Disturbance of these black surfaces (logging activities) increases the albedo and reduces surface temperatures. In addition, woody debris creates shaded microsites that enhance tree seedling and native flora survival.
- Amount of dead and dry fuel loading is reduced. Future risk of "reburns" is reduced.

Cons to salvage logging:

- Logging increases surface erosion by further disturbing soils. The more a soil's structure is disrupted, the greater the potential for surface erosion.
- Logging vectors noxious weed seeds. Severely burned soils are very susceptible to noxious and exotic plant invasion. Existing data indicates that noxious weed abundance can increase threefold following fires.
- Logging removes standing trees that provide shade for microsites.
- Logging removes biomass needed for soil nutrient recycling.
- Removal of standing dead trees reduces habitat for cavity nesting birds and their potential food source (beetle larvae that feed on dead trees).

Pros and cons of salvage logging in perspective

Burned areas, particularly those with severe fire effects must be considered "ecologically sensitive," especially during the first several years following the fire. Water is the greatest source of soil erosion in Inland Northwest forests – therefore, the benefits of increased infiltration rates due to soil disturbance must be weighed against the potential of greater soil erosion.

Logging activities immediately after a fire event have the greatest beneficial potential since this is also when water infiltration rates are lowest and erosion rates the highest. This is also when seed-bed modification may enhance recovery rates of desirable native plants. Logging during the growing season six months following fires may have the greatest detrimental effects by disrupting plant recolonization.

In the spring and summer following a fire, specific native "colonizer" species such as fireweed have been shown to rapidly invade severely burned areas. Surveys of lower elevation sites that burned in the Bitterroot during 2000 have shown that fireweed provides approximately 50 percent surface cover, helping to stabilize soils. Logging during the growing season on such sites can have significant detrimental soil effects, as the stabilization associated with such early successional plants will be disrupted. Logging on a snowpack or frozen ground in the years following a wildfire may alleviate some of these negative effects.

Although noxious weeds may be vectored by logging activities, proper treatment of equipment prior to transport into burned areas can be very effective at reducing this risk.

Many members of the Montana Logging Association have participated in weed workshops where such practices are taught. Other factors such as human use (mushroom picking for example), wildlife and existing weed sources must also be taken into consideration.

Shading effects of dead standing snags and logging debris should theoretically increase colonization rates of native plant species and tree seedlings. Which has the greater effect is often debated. The commonly accepted average temperature lethal to plants is 125°F (55°C) for one minute. Since measured surface temperatures are commonly above 150°F on burned sites, beneficial effects of shade created by materials more than three feet above the soil surface is minimized due to the rapid movement of that shade with the sun. Logs that are horizontal across the soil surface will have a greater shade effect for the creation of microsites. This may be a positive aspect of salvage logging if logging debris is properly distributed.

Research indicates that roughly 90 percent of the nutrients incorporated by tree biomass are located in small diameter structures such as twigs and needles. Salvage logging removes larger diameter bole wood that is suitable for lumber production and leaves the finer materials. The role of larger diameter woody debris in soil development has also been recognized as important, and therefore, should be taken in consideration. Typically, logging results in a significant number of large diameter logs with too much defect for mills. Proper distribution of these materials across the landscape should be an important component of good slash management.

Woody organic matter becomes an important soil component when it has reached advanced stages of decomposition and is capable of retaining large quantities of moisture. At this point it is also a lesser contributor towards wildfire risk. In contrast, dry intact logs represent a considerable risk for severe fire effects. In any fire-prone ecosystem, the potential soil benefit from decomposed organic debris is offset by the high fire risk period while organic debris is decomposing. Depending on the forest type, a log may require between 20 and 200 years to reach an advanced stage of decomposition. During this time, the site is at risk of soil degradation from a severe fire. The higher the organic debris component, the higher the potential soil benefits, but also the higher the risk of losing it all from fire.

There is substantial evidence that standing dead or dying trees resulting from wildfires do provide habitat for a variety of wildlife. Most of the species involved are categorized as fire "opportunists" that benefit from fires but are not dependent on the effects of wildfires. Nonetheless, leaving fire damaged/killed trees for wildlife habitat is an important consideration. In an attempt to provide for this need, many salvage logging protocols call for certain numbers of large diameter leave trees per unit area. While this may be helpful for some species, other research indicates that wildlife such as Black-backed woodpeckers require dense stands of fire-affected trees. Therefore, leaving patches of fire killed trees along with other areas that have widely distributed snags may be the best approach. Much additional research is needed to answer questions of how much, in what distribution, and what species of trees are needed.

Based on this brief summary of the issues surrounding salvage logging, it is apparent that there are potential ecological benefits from salvage logging and potential ecological detriments. The ecological side of the question: "Should salvage logging occur?" is really one that revolves around the magnitude of the fire effects.

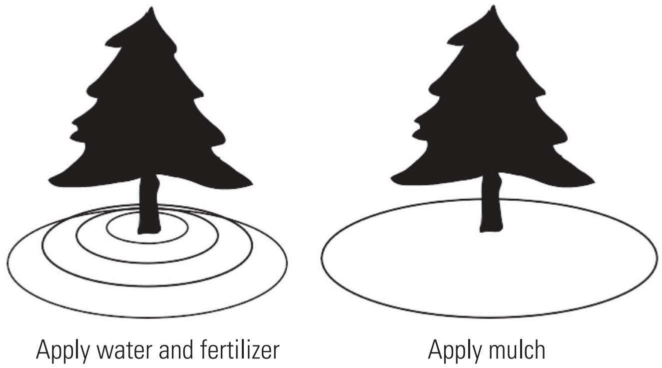
Removal of all trees killed by fire will have a potentially negative impact on wildlife and may reduce soil productivity in the long term. Removal of some of the trees coupled with sound slash management has the potential of decreasing soil surface erosion, decreasing future risk of severe wildfire effects and increasing recovery rates of desirable vegetation. No manipulation of severely burned areas will result in soil erosion risks, future severe wildfire risks and conversely, a large pool of organic matter for wildlife use and future soil amendments. The larger the area affected by fire, the greater the possibility of creating a mosaic of salvage and no-salvage logged areas that could enhance the benefits from both.

What to do to help trees

Water and fertilizer

If the tree has survived the fire with some scorch damage it is important to help the tree recover. Loss of leaves or needles results in the tree not being able to produce the sugars and starches it needs to live. Depending on the time of year and the tree species, some trees will try to grow new leaves. Watering and fertilizing trees with ornamental value (such as those around the house) with a mild solution of balanced fertilizer (10-10-10: ¼ lb. dissolved in 3 gallons of water and applied in concentric circles around the tree base (Figure 5, page 19) will help trees re-grow leaves, either immediately after the fire or the following spring. If the fire occurred in August

FIGURE 5.



or later, it is best to fertilize in the fall after freezing temperature has set in so as not to stimulate new growth that will not have time to become frost hardy.

Stem care and pruning

Fire-blackened tree stems can absorb too much solar radiation, causing the living tissue under the bark to die. For trees that have ornamental value, it may be worthwhile to try and protect stems from getting too hot from the sun. Deciduous trees (most broadleaved trees) are most susceptible to this because of their thin bark. An application of lime or white latex paint on the south side of the tree will help keep the stem cooler. No oil based or petroleum products should be used, as they can kill the tree.

If your tree has survived the fire but suffered some damage, proper pruning will help it recover more quickly. Dead branches will remain on the stem for a long time and act as entrance areas for pests and pathogens. Any time a branch is removed, it should be cut off flush with the stem so that no “stobs” are left protruding (Figure 6). An easy rule of thumb to follow is: if you can hang a coat or hat from the residual branch stob, it is too long.

When pruning, it is important to recognize that conifers and deciduous trees will recover differently from fire damage. If the lower branches of a pine, spruce or fir tree are killed by fire, the tree will not re-grow these branches. A deciduous tree, on the other hand, will often re-sprout new branches either from where the dead branch attached to the stem or along the base of the tree. For both conifers and deciduous trees, it is important to prune off dead branches (Figure 7). Deciduous trees will require subsequent pruning to encourage strong new branches to form. If no follow-up pruning is done the tree will not know which branch to put its energy into, resulting in clumps of weak and poorly formed branches.

FIGURE 7.

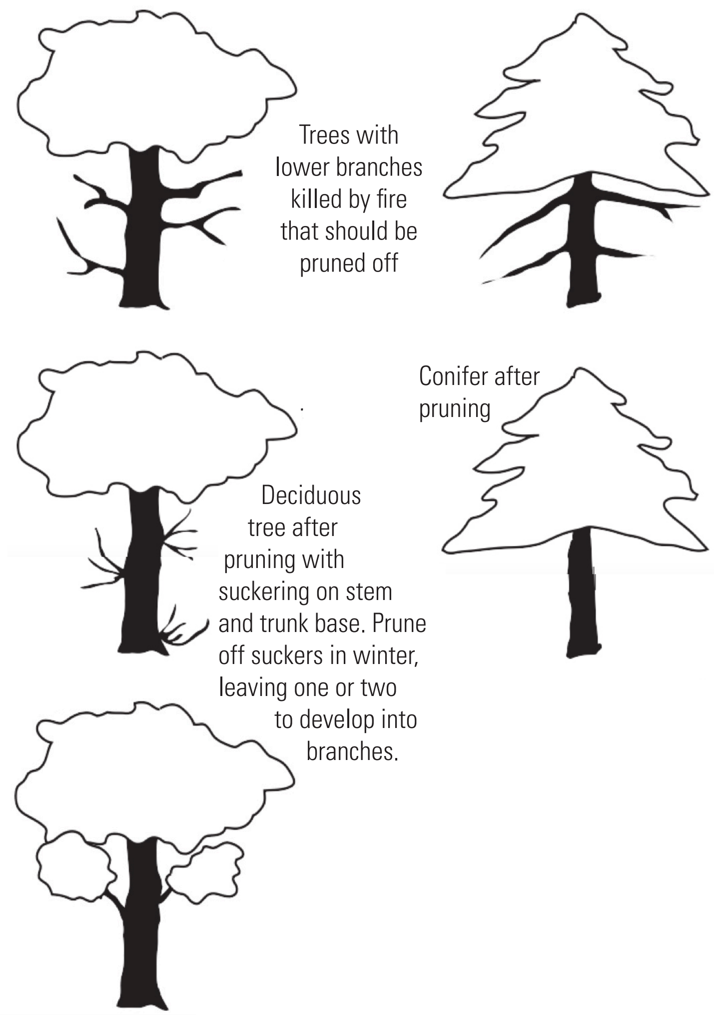
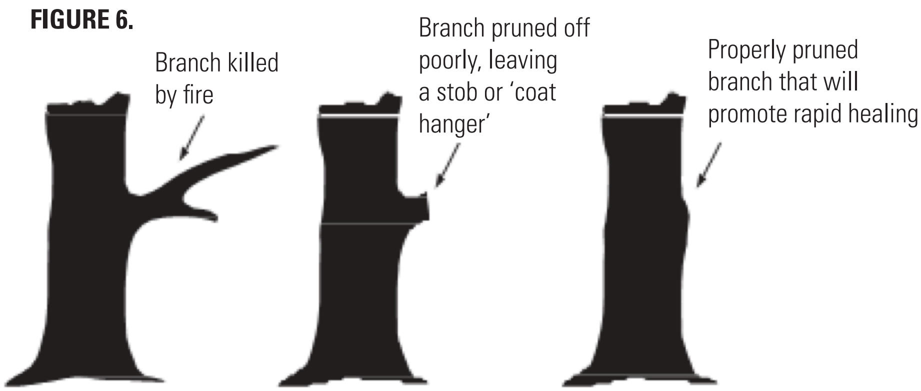


FIGURE 6.



Reestablishing Pastures and Hay Meadows After Wildfire

Dennis Cash, *retired Extension Forage Specialist, Department of Animal and Range Sciences*
Updated by Emily Glunk, *Extension Forage Specialist, Department of Animal and Range Sciences, Montana State University (August 2017)*

Wildfires have been prevalent in the northwestern U.S. during the recent drought, and much money and effort is being spent to recover from fire damage. Occasional fire and frequent drought cycles in the West have been a major historical influence on the types and condition of vegetation in our forests, intermountain meadows and range-lands. Other papers in this series address the restoration of forest and rangeland health after wildfire, maintaining water quality, options for controlling weeds, feeding alternatives and economic considerations. This paper specifically addresses the major considerations for reseeding and re-establishment of desired forage species after fire.

Forage stand condition after burning

Fire has always played a major role in forest and rangeland history. The effects of fire on heavily forested areas may last for centuries. On rangelands and pasture, the effect of fire may range from being beneficial to being equivalent to resulting in severe overgrazing. Extensive forest and prairie fires occurred in the third, fifteenth, sixteenth and eighteenth centuries, and these were caused by humans, lightning and possibly even meteorites. Vast fires were used by Native Americans to haze wildlife to desired hunting areas. The resulting fresh growth of grasses in burned areas attracted game animals and fowl for fall hunts. Fire was widely used by settlers to rid land of timber and brush prior to cultivation. Prescribed burning is still an economical method to control undesirable brush, enhancing carrying capacity and reducing the risk of future, uncontrollable wildfires. In fact, the benefits of annual burning of hayland and pastures were debated into the early twentieth century. In irrigated grain or grass seed production, controlled burning remains a major and inexpensive method of residue, disease and weed control. However, this practice is rapidly disappearing due to public pressure.

Burning a pasture or hay field can have several effects. Early in the season, cheatgrass can be controlled in fencerows, roadways or pastures with minimal negative effect to a pasture. Shallow-rooted forages such as some of the fescue species may survive burning, but must be monitored to ensure that overgrazing of the re-growth does not diminish pasture health. Burning in the fall is more critical. Some perennial plants may be killed outright, or predisposed to winterkill. Fire destroys the plant litter, which results in the loss of organic matter and sets the soil up for erosion problems, depending on slope and winter precipitation. Further, burning can reduce stand productivity and competition, resulting in weed encroachment. In short, a recent one- time burning of a hay meadow or pasture may have resulted in a range of consequences – from complete loss of desirable forage vegetation all the way through a beneficial effect. Successful restoration requires prompt action with appropriate tools.

Timing and degree of fire loss

Immediately after a wildfire, several conditions should be assessed. Following "low intensity" burns, the soil color is still normal, debris is only partially burned, ash is dark in color, and water infiltration is not greatly affected. In these conditions, many plant species will recover in the first year. With "high intensity" fires, the upper 4 inches of soil may be discolored and physically crusted (which reduces permeability), debris and thatch is gone, ash is light in color, and plant survival may be limited. Depending on slope and time of year, the burned site may require immediate attention, or reseeding could be postponed until better conditions exist. If erosion is a risk on slopes, it may be necessary to immediately plant a fast-growing annual crop such as wheat, barley, or oats, prior to reseeding an entire meadow. A producer should consider the previous vegetation and take steps to improve it. For example, if there were patches of invasive weeds or other undesirable plants, it is advisable to wait for one season and control these with herbicides and other methods before reseeding. During the season following a fire, grazing management may need to be adjusted to allow better recovery of the grasses and vegetation. At this point, if the stand and plant community appear to be undesirable, then the producer should take steps to re-seed.

Selecting forage species for reestablishment after fire

There are a number of alternative goals and methods for replanting a burned meadow or pasture. In reseeding projects, producers should review their forage needs, the characteristics of the site, and the potential costs and benefits of a reseeding project. In most cases, a reseeding project is a golden opportunity to expand hay acreage or allot more pastures for different uses, such as early or deferred fall pastures. Depending on the objectives and site, there are many possible

TABLE 1. Considerations for renovating pastures or hay meadows after wildfire

Goal	Aesthetics	Return to natural condition.
	Improvement	Carrying capacity and profitability.
Condition	Previous vegetation	What was the previous production?
		Were invasive weeds already present?
	Severity of burn	Will the preexisting forages recover?
Site	Topography	Will the slope cause erosion?
		How close to riparian areas and stock water?
		Will I need immediate cover?
		Can I plant with a drill?
	Elevation	What is the frost-free-period?
		What species will survive and produce well?
	Precipitation	What is total and seasonal distribution of precipitation?
		How deep is the water table?
Intended use	Hay	How accessible is the site?
		Strictly hay or will the “stockpiled” forage be fall grazed?
	Early spring	Will this pasture provide “rest” for native range?
		Is it accessible at this time of year?
	Summer	Is this normally a forage-deficit period?
		Is livestock water available?
		Is forage availability and quality adequate?
	Fall or winter deferred	What class of livestock?
		How late is the site accessible?
Management	Planting	What equipment is required and available for planting?
		Which species are “easy” vs. “difficult” to establish?
		Which species are compatible in a mix?
	During establishment year	Are mowing and spraying necessary for weed control?
		Is fertilization necessary?
		When can the stand be grazed?
	Long-term	What is the best grazing strategy?
		Which species have the best production potential?
		Which species are long-lived?
		Can grazing management, fertilizer, weed control, etc. provide for “infinite” stand life?

choices of grass species, cultivars and mixtures. Cool season grasses initiate early spring growth using winter moisture, and produce seed in early summer. A mixture of cool-season grasses with deep-rooted legumes or forbs can provide season-long forage. On many public lands, federal or state agencies are responsible for restoration with native species of grasses, forbs and shrubs. On private lands, a producer may elect to renovate using native plants, or monocultures or mixtures of any number of improved forage species. Native plants are generally slow to establish, but are adapted for long-term survival at a specific site. Introduced plants are generally quicker to establish, and can provide earlier productivity and stabilization. Regardless of whether native or introduced species are used, there are several factors to consider in selecting a forage species or cultivars for reseeding after a destructive fire (Table 1, page 21).

For revegetation after wildfire, a producer may opt to plant an adapted, introduced species – these are generally easier to establish, and have high production potentials with good moisture. In most situations, a single species or a simple mixture is most suitable; however, a native species will generally not compete in a mixture with introduced species, so competitive ability of each species needs to be considered.

Further, consider differences in growth habit, season of use, and differences in palatability when choosing a seed mixture. There are innumerable forage mixtures possible – some examples for specific conditions are shown in Table 2.

Complex seed mixtures are often used after wildfire to help prevent weed invasion and provide plant diversity for wildlife. Mixtures including several species of grasses and forbs tend to utilize moisture, light, and nutrients throughout the season, providing good weed competition. However, over time, a complex mixture is more difficult to manage in terms of grazing and weed control, and will typically evolve into a simple mixture. The best option for most producers is to have

TABLE 2. Examples of forages and seed mixtures for specific site conditions for reseeding after wildfire

Site Type	Goal	Mixture/Species	PLS/Acre*
"Dry, warm" (Open grasslands at low elevations/all aspects or south and west aspects at higher elevations)	Quick cover, competition	1. 'Covar' sheep fescue	3.0
		'Pryor' slender wheatgrass	2.0
	Maximum cover, good forage potential	2. '759' pubescent wheatgrass	9.0
		'Covar' sheep fescue	1.5
		'Pryor' slender wheatgrass	2.0
"Moderate" (Moist, warm environments found on north or east slopes at low elevations, all aspects at mid-elevations, or south and west slopes at high elevations)	Maximum cover, moderate forage potential	3. 'Critana' thickspike wheatgrass	5.0
		'Durar' hard fescue	1.5
		'Pryor' slender wheatgrass	2.0
	Maximum cover, good forage potential	4. 'Rush' intermediate wheatgrass	9.0
		'Durar' hard fescue	1.5
		'Pryor' slender wheatgrass	2.0
"Good to Excellent" (Old, improved or unimproved hay meadows with known good production potential)	Good cover, good pasture potential	5. 'Paiute' orchardgrass	3.0
		'Durar' hard fescue	1.5
		'Pryor' slender wheatgrass	1.0
	Rapid cover, very early pasture	6. 'Hycrest' crested wheat grass	5.0
	Grass Hay	7. 'Climax' timothy	4.0
	Good cover, one cut of hay and stockpiled forage for fall pasture	8. 'Ladak 65' alfalfa	4.0
		'Paiute' orchardgrass	2.0
	Tall cover, fall-winter deferred pasture	9. 'Prairieland' Altai wildrye	6.0
		'Remont' sainfoin (seeded in alternate rows)	17.0
	Wet, poorly drained soils for pasture or hay	10. 'Palaton' reed canarygrass	6.0
		Alsike clover	2.0

Mixtures 1 to 5 adapted from T. Wiersum, Joe Fidel and T. Comfort, 2000, "Revegetating After Wildfires," USDA-NRCS Fact Sheet.
*Authors recommend doubling these seeding rates for severely burned areas

a series of pastures or meadows dedicated to different seasons of use. Many introduced species such as crested wheatgrass and Russian wildrye are very competitive with invasive weeds, and weed management in a pure grass stand is fairly easy.

Grass-legume mixtures are very productive for hay, pasture, or hay- stockpile systems. These mixtures generally provide more high-quality forage than a grass seeded alone. Some legumes such as alfalfa have long taproots that draw water and nutrients from deep in the soil, enabling the legumes to grow productively during dry periods. Also, legumes increase the level of protein and energy in the forage. A preferred method of seeding grass-legume mixes is to drill alternating rows of each crop. Alfalfa-grass mixtures may require more intensive grazing management, but in most cases, the benefits out- weigh the potential bloat risk. The bloat hazard can be eliminated by substituting the alfalfa with sainfoin, cicer milkvetch, or birdsfoot trefoil. Additionally, adding a legume to the mixture will help to improve overall pasture protein and digestibility, leading to improved overall animal performance.

Cultivars and seed sources of forage seed

After selecting an appropriate species or mixture for a reseeding project, a producer should choose a good cultivar (variety). The Montana Agricultural Experiment Station and the NRCS Plant Materials Center at Bridger, MT, conduct extensive forage variety trials for adaptation, forage yield, and persistence. Producers should choose cultivars that have performed well at sites similar to their own. Once a cultivar has been chosen, a producer should purchase seed from one of the many reputable seed dealers in Montana.

Federal and state seed laws require that seed is labeled as to origin, purity, species identity, percent germination and content of other crops or weed seed. For most reseeding projects, certified seed should be used where possible. Certification ensures genetic and mechanical purity, cultivar identity, uniformity, and reduces the risk of weed contamination, particularly noxious weeds.

Uncertified or common seed from Montana and other states can be used for reseeding projects, however the seed should have originated within 300 miles of the intended planting site (to assure adaptation), and should have a tag with recent purity and germination data. Unlabeled seed that has not been evaluated for purity increases risk of weed introduction and contamination, and should be avoided. For more information on forage varieties and availability, the reader should contact a local MSU Extension agent or local NRCS field office.

Planting methods

Planting technique can often influence establishment and performance much more than differences among species. Forage seed requires precise, shallow placement in a firm seedbed that is free of competition from weeds or other plants. Planting forages on cropland, particularly dryland, is often challenging and reseeding meadows after wildfire can also be difficult. Further, the seed cost for some species can exceed $40 per acre, so producers must make every effort to use appropriate equipment and methods to maximize the odds for a successful stand. The concepts for reseeding a hay field or meadow after wildfire are the same as those for farm ground. A burn area may require immediate action, but aside from potential equipment or accessibility limitations, all steps discussed below should be followed.

Seeding rates

Proper seeding rates for forage grasses or legumes specify planting 20 to 50 viable seed per square foot, depending on species. The actual recommended rates vary depending on known differences in seedling vigor, on difficulty in metering very small amounts of seed with conventional equipment, and on dryland vs. irrigated conditions.

Another concept in forage crops is "Pure Live Seed" (PLS). As opposed to large seeded crops, such as grain, beans, etc., seed lots of many forage species may contain dormant, dead or ungerminable seed, seed coatings or inoculum, or other particles. The PLS content of a seed lot is calculated by multiplying the purity percentage by the germination percentage, then dividing by 100 (germination test must be current). For legumes, the percentage of "hard" seeds is added to the germination percentage before calculation.

There is a wide range in seed sizes among the forage species. For example, in the species listed in Table 1, seed size ranges from about 30,000 (sainfoin) to about 2.2 million (Kentucky bluegrass) seeds per pound. For successful forage seeding, producers must properly place the recommended number of PLS per square foot of soil. For example, in a new seeding of crested wheatgrass with a purity of 98.5% and germination of 84% (PLS = 82.7%) a seeding rate of 6 pounds per acre (Table 1. Value of 5 pounds per acre/0.827) would be required. For seed mixtures, the number of pounds of PLS of each species is calculated separately, and then divided by the number of species in the mixture. A great deal of early agronomic work with Montana's forage crops has resulted in appropriate "recommended" PLS seeding rates for both dryland

and irrigated conditions, as shown in Table 1. (See your local MSU Extension county agent or NRCS field office for more details.)

Site preparation and timing

Forage planting is most successful on a "conventional" seedbed – ground that is firm, mellow, moist, and free of weeds, debris and large clods. Rough or fluffy seedbeds result in slow and erratic stand establishment, which delays using the new pasture and presents a higher risk of weed encroachment. Reseeding after wildfire can eliminate many of the obstacles for seedbed preparation. However, in many cases proper equipment and accessibility are limiting.

For dryland seedings, moisture during establishment often dictates the success of a new forage stand. A general guideline for planting forages is that there should be a minimum of 2 feet of soil moisture for successful plant establishment. On dryland, planting should occur very early in the spring to capitalize on late snows and early rains. "Dormant" or "frost" seeding of grasses (but not legumes) is successful in the late fall or winter, as long as temperatures and moisture remain low enough to prevent germination before the spring. Late summer planting (prior to August 15) should only occur if supplemental water is available from irrigation or stored soil moisture. With irrigation, it is possible to plant from the spring until mid-August (allow for emergence 4 to 6 weeks prior to first frost). The soil can be tilled in the fall or early in the spring prior to seeding. On dryland, the field is typically summer-fallowed for one year to accumulate soil moisture, then seeded the following year.

TABLE 3. Forage species used to reseed pastures and hay fields after wildfire
(Note: These seeding rates are for dryland; under irrigation seeding rates are increased by 30%.)

Precipitation*	Species	Native (N) or Introduced (I)/Growth Habit	Other	Seeding Rate**
<10	Thickspike wheatgrass	(N) Tall, rhizomatous	Easy to establish; spring, summer and fall use; good salt tolerance	5
	Bluebunch wheatgrass	(N) Medium-tall bunchgrass	Fairly easy to establish; spring and summer use	7
	Siberian wheatgrass	(I) Short bunchgrass	Easy to establish; spring use	6
	Crested wheatgrass	(I) Medium-tall bunchgrass	Easy to establish; spring and fall use	5
	Russian wildrye	(I) Tall bunchgrass	Difficult to establish; all seasons; good salt tolerance	
	Sweetclover (yellow or white)	(I) Tall legume	Easy to establish; spring and summer use	4
10 to 13	Slender wheatgrass	(N) Tall bunchgrass	Easy to establish; spring and summer use; good salt tolerance	6
	Streambank wheatgrass	(N) Medium-tall rhizomatous	Fairly easy to establish; spring, summer or fall use; good salt tolerance	5
	Western wheatgrass	(N) Medium-tall rhizomatous	Fairly easy to establish; summer and fall use; good salt tolerance	6
	Basin wildrye	(N) Very tall bunchgrass	Difficult to establish; early spring or winter use	6
	Sheep fescue	(I) Short bunchgrass	Fairly easy to establish; summer use	3
	Tall wheatgrass	(I) Very tall bunchgrass	Easy to establish; spring summer or fall use; excellent salt tolerance	10
	Intermediate or pubescent wheatgrass	(I) Tall rhizomatous	Easy to establish; spring, summer or fall use	7
	'Newhy' hybrid wheatgrass	(I) Tall, semi-rhizomatous	Easy to establish; spring, summer or fall use; excellent salt tolerance	8
	Alfalfa	(I) Tall legume	Easy to establish; spring, summer or fall use	5
	Sainfoin	(I) Tall legume	Easy to establish; spring, summer or fall use; non-bloating	34

continued on page 25

On farm ground, forages are typically planted on land that has been harrowed to bury crop residue, then packed. Depending on irrigation availability, crops in the rotation, weed pressure, and available equipment, several different implement combinations can be used to plant forages.

Following sod or an old hay field, deep plowing or ripping is typically used in fall to bury residue and break potential hardpan layers. The field is then tilled with a heavy offset disc harrow to break up the large clods.

Following an annual grain crop, tillage may simply consist of disc harrowing. Prior to seeding a forage, soil must be pre-packed with a cultipacker or roller. Pre-packing is necessary to assure proper seed depth, to provide good seed-to-soil, and to reduce drying. Seeding can be done using the grass seed attachment on a conventional grain drill, a no-till drill, or a broadcast-packer seeder (for example the Brillion). Double-disc openers with depth bands work best, but double discs without depth bands or hoe openers can be modified to work. The seedbed must again be packed – with the packer wheels on the grain drill, or as a separate operation.

Reseeding into sub-irrigated meadows is often difficult because high water tables may be present until mid-summer. A wildfire may offer an excellent opportunity to upgrade and improve these meadows, because competing vegetation and much of the debris is removed. One option would be to wait until the year after the fire (to evaluate the need for reseeding), then if necessary, suppress the existing vegetation with a contact herbicide in the early summer.

Seeding should then be done prior to mid-August, or by dormant seeding.

Seed placement

Forage seeds are much smaller than small grains, and must be planted at a uniform, shallow depth (< ½ inch). Emergence of forage seedlings is often slow, therefore competition from existing crops or weeds can reduce the success of a new stand.

continued from page 24

14 to 16	Idaho fescue	(N) Short bunchgrass	Difficult to establish; spring, summer or fall use	3
	Canada wildrye	(N) Medium-tall bunchgrass	Fairly easy to establish; spring and summer use	7
	Mountain bromegrass	(N) Medium-tall bunchgrass	Easy to establish; spring and summer use	10
	Hard fescue	(I) Short bunchgrass	Fairly easy to establish; summer use	3
	Kentucky bluegrass	(I) Short rhizomatous	Easy to establish; spring and summer use	2
	Altai wildrye	(I) Tall rhizomatous	Difficult to establish; any season	12
	Smooth bromegrass	(I) Tall rhizomatous	Easy to establish; spring and summer use	5
	Meadow bromegrass	(I) Weakly rhizomatous	Easy to establish; spring, summer or fall use	8
	Orchardgrass	(I) Tall bunchgrass	Easy to establish; spring, summer or fall use	4
	Red or Alsike clover	(I) Tall legume	Easy to establish; spring and summer use; Alsike clover tolerates wet soils	6
	White clover	(I) Short legume, stoloniferous	Easy to establish; spring and summer use	3
	Cicer milkvetch	(I) Tall, rhizomatous legume	Fairly easy to establish; summer and fall use; non-bloating	7
	Birdsfoot trefoil	(I) Short, decumbent legume	Fairly easy to establish; summer and fall use; non-bloating	5
16 to 18	Tall fescue	(I) Medium-tall bunchgrass	Easy to establish; spring, summer and fall use	6
	Timothy	(I) Tall bunchgrass	Easy to establish; spring and summer use	4
>18	Creeping foxtail	(I) Tall rhizomatous	Fairly easy to establish; spring and summer use; tolerates high water table	3
	Reed canarygrass	(I) Tall rhizomatous	Difficult to establish; spring and summer use; tolerates high water table	4

*Minimum annual precipitation (inches)
**Seed Rate for Pure Stand, Pounds of Live Seed (PLS)/Acre

Further, many forages have seed dormancy or require cold stratification to germinate. Crested, intermediate or pubescent wheatgrass are among the easiest to establish – under ideal seedbed and growing conditions, good stands are easily attained. In contrast, if planting occurs into dry soil followed by only a small amount of precipitation, a complete stand loss immediately after emergence could occur. Russian and Altai wildrye are generally more difficult to establish, and these may do best if dormant-seeded.

Broadcast planting can be successful. However, tillage, followed by both pre- and post-plant packing, is required. Currently, many fertilizer application units in Montana can accurately apply forage seed, and this has become popular. Broadcast seeding can also be done with a "whirlybird" spreader operated by hand, or mounted on a four-wheeler or tractor. Many inaccessible areas are seeded by aircraft.

For many situations after wildfire, broadcast planting may be the best option for reseeding forages. In this case, the soil may already be in a firm, weed-free condition. It may be necessary to scratch the soil with a pasture drag before broadcasting, followed by seeding, then packing if possible. For all broadcast seedings, the recommended seeding rates should be doubled to offset seed that are placed too deep or too shallow. (This corresponds to the double seeding rate recommended by the NRCS for revegetation projects following a severe burn; seeding rate should be 2X the rates listed in Table 3, page 25). Broadcast seeding immediately prior to heavy snow in the fall is often very successful.

Companion or "nurse" crops

For steep slope or riparian areas that are burned and subject to erosion, it is advisable to establish a quick ground cover immediately after wildfire. Several options that had been recommended in Montana following the 2000 fire season were annual ryegrass (10 pounds per acre) or barley, spring wheat or winter wheat (30 pounds per acre). These species are still advised, although care should be taken as annual ryegrass may act as a biennial and can be invasive in some situations. Still, it is critical to use certified seed, or seed known to be weed-free. These are fast-growing annual crops that establish quickly to reduce erosion, then depending on conditions they make a seed crop and die. Nurse crops are not typically recommended for mixed seedings with forage crops, due to competition. However, after a wildfire, a companion crop may be useful for areas with a mixed slope or other conditions that may limit quick establishment of the perennial forage seeding. If a companion crop is used, then reduce the seeding rate by 50 percent or more (10 to 15 pounds of grain) to reduce competition with the perennial species. It is also advised to harvest the companion crop early to limit competition.

Management during establishment

Stand establishment of forages can be quite variable. When irrigated, emergence and stand success have few risks. However, even with all of the right seeding techniques, conditions in non-irrigated fields can be slow and frustrating. Many of the grasses have seed dormancy, and hard seed in legumes can sometimes provide for the opportunity of emerging later and "filling in."

Regardless of initial stand density, it is likely that weed control will be necessary. Weeds can be controlled by clipping (before seed heads form), or using labeled herbicides. Many hay fields and meadows are deficient in major nutrients necessary for optimum forage production – nitrogen (N), phosphorus (P), potassium (K) – and possibly several minor elements such as sulfur. Recommended annual levels of N, P and K for grass are shown in Table 4 (page 26). Forage production is very responsive to fertilizer and in most studies an economic response can be shown when the soil is deficient in one or more nutrients. Following a wildfire,

TABLE 4. Recommendations for annual N, P and K fertilization for grass hay or pastures.

		Soil P test level (parts per million, ppm)				Regardless of Yield Potential	
Yield Potential (tons/acre)	Fertilizer + Soil Test Level of NO_3-N (pounds/acre)	4	8	12	16	Soil K test	Apply K_2O
		Apply P_2O_5 pounds/acre				ppm	pounds/acre
1	20	12	10	8	5		
2	40	21	17	12	8	0	80
3	60	29	24	18	11	50	64
4	85	38	31	22	13	100	48
5	115	46	38	26	15	150	24
6	155	55	45	30	17	200	0

From: J. Lichthardt and J. Jacobsen, 1992, *Fertilizer Guidelines for Montana*, Montana State University Extension EB104.

it may be advisable to wait until a stand is established, then submit soil samples for laboratory analysis. Based on the soil test, you could then fertilize late in the same summer or the subsequent spring.

New seedings should be protected from grazing until they are well established to ensure their long-term survival and productivity. A guideline for many cool-season grasses is to avoid grazing until most of the field has seed heads. Under non-irrigated or dry conditions, this may require one complete season. With moist conditions, a new pasture of orchardgrass may form seed heads during the first year, but grazing should be postponed until after a hard frost to minimize plant damage. There are also a number of steps for designing grazing systems. After establishment, vigorous, well- maintained pastures and hay fields should have minimal weed problems. Weeds should always be monitored, and an integrated plan that includes good crop culture, proper grazing and recommended herbicides can provide for long-term weed management.

For hay crops, most forages can be cut at any time during the growing season. A critical management step for long-term survival and productivity of many cool-season forages in Montana is to not cut or graze in the period from early August (30 to 45 days prior to average first frost) until a "killing" frost (typically mid-October, with several successive days of temperatures around 25°F). This allows roots to replenish carbohydrate levels for winter survival and early spring growth.

Summary

Wildfire is a common occurrence in the western U.S. Although challenging in many respects, wildfires can provide an excellent window of opportunity to reseed hay fields or meadows with improved forage species. Many areas burned by wildfire have difficult accessibility, and producers are often limited in equipment for properly seeding forage crops. Most of the techniques and concepts used for seeding forages on cropland apply to forage reseeding projects after wildfire. A producer should do a thorough site evaluation after a wildfire. Steep areas will likely need immediate attention, but other meadows or hay fields might be observed for a period of the growing season after the burn to assess the need for and steps to proceed with reseeding. Many improved forage species and mixtures can be used for reseeding. These should be chosen based on the site conditions and the particular needs of the producer. Proper seeding and management techniques described in this paper will help optimize the success of a reseeding project after a wildfire.

Electric Fencing to Exclude Deer and Elk from Recovering Burned Areas

Jim Knight, *retired Extension Wildlife Specialist, Department of Animal and Range Sciences, Montana State University*
Lisa Schmidt, *former Madison-Jefferson County Agent, Montana State University Extension*
Updated by Lance McNew, *Assistant Professor of Wildlife Habitat Ecology, Department of Animal and Range Sciences, Montana State University (August 2017)*

Following forest or range wildfires, it is often necessary to eliminate grazing for a period of time to allow vegetation to recover. Controlling livestock grazing, although expensive for the rancher, can be accomplished by putting livestock in other pastures. Controlling the use of areas by large ungulates is much more difficult.

Several methods to control deer and elk have been used with varying levels of success. Repellants such as periodic explosions and odors can be effective for limited periods, but are not long-term solutions. The more desperate the animals are, the more likely they are to put up with noises or odors. Food may be scarce after a wildfire and deer and elk will tolerate more disturbances than they would if food sources are abundant.

Exclusion, although expensive, is usually the most effective method to protect large areas such as pastures or revegetated forestlands.

Fencing to exclude elk and deer from pastures

Fences are the most effective way to protect vegetation over the long-term. Several types of fences are available to exclude elk and deer. One must first consider the cost of constructing and maintaining the fence as well as the effectiveness of the fence. Seven-foot woven wire fences have proven to keep elk and deer out for up to 30 years, but they are expensive to construct (Table 1). Barbed wire fences are less expensive to construct, but are usually less effective and require more maintenance. Electric fences are relatively inexpensive to construct and will effectively exclude elk and deer if constructed properly. However, they have a higher maintenance requirement than a woven wire fence.

Constructing an effective permanent electric fence

Electric fences are psychological barriers rather than physical barriers. Whole herds of elk and deer can be repelled by an electric fence when one animal is shocked. Others in the herd see the reaction to pain and identify the electric fence as a threat. For electric fences to be effective psychological barriers, they must consistently impose a perceived threat.

High voltage, high tensile 8-wire electric fences will repel both elk and deer. If only elk are a problem, 7 wires will be enough. The fence should be about 6 feet high. The bottom 4 wires should be spaced 8” apart. The next 3-4 wires can be spaced 10-11 inches apart. Every other wire should be a ground wire.

At least 4,000 volts must be continuously maintained in the fence using a high-quality fence charger. Because the hollow hair of deer or elk acts as an insulator, 4,000 volts are required to provide sufficient shock. It is imperative that the fence is charged as soon as any portion is completed. Even if only 100 yards are built in a day and wildlife could easily walk around it, charge that 100-yard segment. Once the fence is constructed, periodically check the voltage with an electric fence tester.

A good ground will ensure that the voltage is high enough to repel elk and deer. Plan to use four ground rods, buried 6 feet apart. Pound 6-foot galvanized rods 5 feet into the ground. Galvanized pipe will provide a good ground, but be sure to cap the top so rainwater does not fill the pipe. If rocky soil prevents driving a ground rod, bury the rod horizontally as deeply as possible and connect insulated ground wires from the fence to it.

Deer and elk will constantly test a fence, so if they find they can penetrate it one time, an electric fence loses its effectiveness. The fences should always be charged. A common mistake is to turn off the electricity during the off-season. This makes the fence ineffective even when it is recharged because the deer and elk have learned they can penetrate it.

Because the fence is a repellant, it is important that elk and deer can see it. Use shiny metal reflectors on wire or use polytape. The shiny reflectors will attract curious wildlife more than almost invisible electric wire. Polytape comes in a variety of colors, but studies show that white provides the most contrast so it is the most visible. Expect to replace polytape every 3-5 years if revegetation will take a longer period of time. If the fence crosses through heavy vegetation, plan to clear a 10-15 foot buffer outside the fence so elk and deer will see it. On steep slopes, the buffer should be wider.

Hot wires can be initially coated with a mixture of peanut butter and molasses. This mixture attracts elk and deer and ensures that the first contact with the fence will be with the tongue or nose instead of the body insulated by hair. To coat wires with the mixture, combine the peanut butter and molasses to the consistency of thick paint, then use a mop glove to spread the mixture along the wires.

Vegetation that touches the fence may divert some of the voltage. If possible, plan to mow vegetation under the fence. If mowing is not feasible, plan another option for controlling vegetation that may short out the fence. Pull grass by hand, cut shrubs with a machete and trim trees with a chainsaw. Herbicides also control vegetation well.

Electric fence chargers can be solar- or battery-powered or use an AC current. AC current chargers are the most reliable and least expensive, but a hard-wire system is not always feasible because many areas are not near electric power sources. Deep-cycle battery-powered chargers and combination solar/battery-powered chargers are good alternatives when main power is not available. Two or more chargers might be more effective if large areas are to be fenced. When designing the electric fence, buy a low-impedance charger with enough power to compensate for stray vegetation or other possible shorts.

Chargers should be located as near the fence as possible. Mount a charger to a wooden post or other stable fixture. Face solar panels towards the south at an angle that faces the sun. A solar-powered charger needs a minimum of 4 to 5 hours of sunlight each day so it can charge the battery. Cloudy days usually will provide enough sunlight to energize a fence, but the battery must be charged so the fence will be energized at night.

Effective temporary electric fences

Two-strand, 17-gauge temporary electric fences have proven effective under moderate deer and elk pressure. The principles behind temporary electric fences are the same as the principles of permanent electric fences. The fence is a psychological barrier rather than a physical barrier. It is important to install this type of fence prior to the time the deer or elk start using the area. Elk and deer must be able to see the fence and be conditioned to avoid it.

Temporary fences are less expensive to construct than permanent fences, but require more maintenance. They are a good option for areas that have heavy snowfall or other conditions, which cause seasonal grounding or maintenance problems.

To construct a temporary electric fence, suspend the hot wire (+) about 36” high and the ground wire (-) about 18” high. Plastic or fiberglass rods are convenient temporary posts; place them 30-60 feet apart. Use wooden posts or T-posts with insulators to support the corners.

Wrap aluminum foil “flags” on the hot wire at 20-50 foot intervals, and then coat the hot wire and “flags” with peanut butter and molasses. If you use polytape, a mop glove can be used to spread the mixture and the foil will not be necessary. Although it can result in sticky conditions, one researcher soaked the whole spool of polytape in molasses before it was suspended.

Keep the fence clear from vegetation that will short out the electric current. Maintain a clear buffer on the outside of the fence so elk and deer will see it.

TABLE 1. Effectiveness and cost of various fence types

Fence	Construction Cost/Mile	Expected Life	Effectiveness
7 ft. woven wire	$4787	30 years	Excellent
7 ft. 10-wire, barbed	$4027	30 years	Good
7 ft. wire Perm. Electric	$4000-$5950	30 years	Excellent
2 wire Temp. Electric	$1310-$1685	10 years	Moderate

*2012 prices. Labor is not included in cost estimates. $283 for a solar-powered electric charger is included in the electric fence estimates. Chargers generally vary in price from $100 to $475.

Rangeland Weed Management after Wildfire

Kim Goodwin, *former noxious weed Project Specialist, Montana State University*
Roger Sheley, *former Associate Professor and MSU Extension weed specialist*
Janet Clark, *former Director, Center for Invasive Plant Management, Department of Land Resources & Environmental Sciences, Montana State University*
Reviewed by Jane Mangold, *Extension Rangeland Weed Specialist, Department of Land Resources & Environmental Sciences, Montana State University (August 2017)*

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 re-initiate 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 necessary, 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 section 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.

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

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.

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.

Noxious weed cover and survival

After assessing the severity of the burn, estimate noxious weed cover before the fire (See Montana County Noxious, page 49) 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 Rhizome-spreading Noxious Weeds of Montana, page 41). 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 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 six-fold within two years of a controlled burn.

TABLE 1. Determining Burn Severity

Burned area characteristics	Low severity	Medium severity	High severity
Soil color and condition	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
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

Adapted from “Fire Burn Severity,” Gallatin National Forest (unpublished).

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 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.

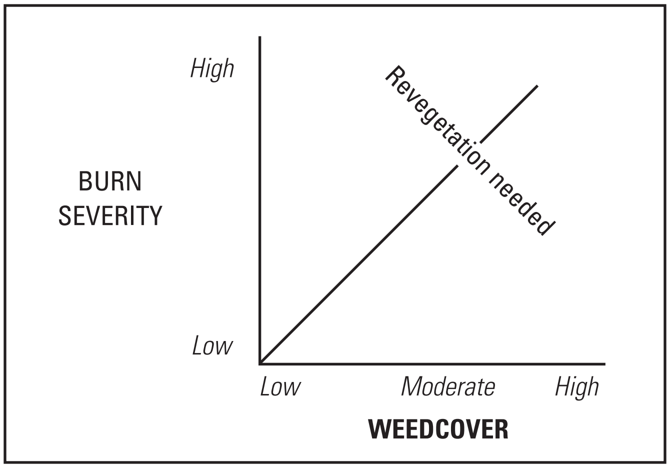


FIGURE 1. Impacts of burn severity and weed cover on the need for revegetation.

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 Figure 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.

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

TABLE 2. Determining the necessity of burned area vegetation

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 benefit regularly monitor for new weeds until com- munity reaches recovery, then monitor occasionally	Revegetation not necessary; ecological effects generally benefit regularly monitor for new weeds until com- munity 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.

burn severity (Table 2, page 32). 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.

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

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 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 Revegetating After Wildfires, page 42.)

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 wheat- grasses 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% sand, 35% silt, and 20% clay.

> *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.

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 tripling 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.
  - 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).
- 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 re-grazed.
- Outline the movement of livestock throughout the year.
- Minimize bare ground by promoting the accumulation of plant litter.
- Monitor 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.

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
- 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

---

SLOPE AND 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 Revegetating After Wildfires, page 42.

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-pulled 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 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.
  - 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 management efforts. Low-density patches respond more quickly than high-density patches to eradication.
- Monitoring the management area for weeds. Document changes in patch size and density at least once a year.
- 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.
- 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.

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.

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, 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.

CHEMICAL CONTROL Herbicides eradicate weeds or greatly reduce weed vigor. Herbicides can reduce photosynthesis, disrupt vegetative growth, or interrupt the production of essential proteins.

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
- 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 non-residual 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

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
- Biological controls, such as weed-damaging insects

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.

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, proper management of desired plants 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.

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

"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 to flowering 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.

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.

(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.)

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.

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.

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.

BIOLOGICAL CONTROL Most noxious weeds of Montana (see Montana Noxious Weed List, page 49) 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, page 40.) 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.

Contact your local 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.

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 (Table 2). 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
- Properly managing established vegetation

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.

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 × 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 the weed management plan.

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.

Page 44 has a schematic or flowchart of a decision-making process that can help a manager prepare a burned-area IWM plan.

TABLE 3. Selected biological control agents

Weed	Agent	Type of agent	Mode of action
Canada thistle	*Ceutorhynchus litura*	Beetle	Stem-borer
Dalmation toadflax	*Calophasia lunula*	Moth	Foliage feeder
Dalmation toadflax	*Mecinus janthiniformis*	Weevil	Stem 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*	Weevil	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

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.

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.

Montana Noxious Weed List on page 49.

REVEGETATING AFTER WILDFIRES

Loss of vegetation leaves land vulnerable to increased runoff, erosion, and sedimentation; encourages weeds; degrades habitat; and impairs forest regeneration. Revegetation is a good step to take toward controlling noxious weed invasion after a wildfire. For more information about weed suppression, you could also contact your county weed coordinators. Reestablishment of permanent vegetation provides long-term erosion control, protection, and site stability. This practice is the least expensive per acre. It directly addresses the resource concerns, and it is best suited to addressing concerns over larger areas.

WHAT AREAS NEED REVEGETATING?

In general, severely and moderately burned sites should be reseeded to decrease the likelihood of erosion and sediment movement down slopes, to discourage weed invasion, and to fulfill management objectives. Since lightly burned areas recover quite quickly from wildfire, reseeding is usually not necessary.

WHEN SHOULD I PLANT?

Grasses and forbs should be planted after the wildfire or ground disturbance when the soil surface is loose. Seeding in late fall or winter (even if there are a few inches of snow) improves success. The prime time to seed is immediately prior to the ground freezing. Trees or shrubs should be planted in the fall or early spring when plants are dormant.

WHAT SHOULD I PLANT?

Perennial grasses and forbs are slower to establish, but provide long-term cover for reseeded sites. Sites to revegetate with perennial grasses and forbs include severely burned sites and moderately burned sites that had populations of noxious weeds before the wildfire or that are less than 50 feet from a drainage channel. For example, slender wheatgrass is a native grass that establishes quickly and is moderately long-lived. Over time, as the slender wheatgrass begins to die out, other native species begin to fill in the site.

Annual ryegrass and small grains are useful when quick establishment is key; however, they only provide one year of protection. Revegetate with annual species where perennial grasses will recover naturally, including moderately burned sites with slopes greater than 15 percent. For example, winter wheat is a good option if native seed varieties are unavailable.

HOW MUCH SHOULD I PLANT?

Most seedings are broadcast with either aircraft or ground equipment. Landowners can seed small areas using a hand-crank seed broadcaster. You should use certified seed of a known variety to get the 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 NRCS, Extension Service, or conservation district office for recommended varieties or substitute species.

The seed mixes in the following charts are appropriate for areas west of the Continental Divide and foothills/mountains east of the Divide. Ideally, you should choose one to three of these species for a mix. The tables give the “pure-stand” seeding rates for each species expressed as pounds of pure live seed (PLS) per acre. To calculate a mix, divide the species rate by the number of species in the mix. Then, take the lbs/ac and multiply by the total acres to be seeded. Double these seeding rates on severely burned areas or steep slopes.

For example, if you are using a mix of three grasses to be seeded on 10 acres, divide the lbs/ac for each species by three and then multiply by 10. For slender wheatgrass the equation would be (12/3)10 = 40 pounds of slender wheatgrass in the mix.

IS THERE ANYTHING ELSE I CAN DO TO HELP THE PLANTING?

Mulching will stabilize the soil surface to prevent movement of soil particles and loss of seed. Use straw or grass hay mulch or netting on small areas of steep slopes. Apply mulch at 70 lbs/1,000 sq. ft. (about 43 bales per acre). Use weed free material. Do not fertilize the first year. Hydromulching should be done in two operations. First, use a mulch-seed mixture to distribute the seed. Then, use the remaining mulch over the top to increase contact of seeds with the soil.

Keep your work well-maintained by repairing any spots of failure with new seed, plants, and mulch. Fertilize after the first year in spring until vegetation is well established.

Retrieved December, 2017 from: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/mt/programs/planning/ewpp/?cid=nrcs144p2_056245

WHAT SEEDING RATES SHOULD I USE?

ZONE 1 is made up of dry, warm sites consisting of open grasslands and woodland benches at low elevations on all aspects and on south and west-facing slopes at higher elevations. Woodland sites are dominated by dry Douglas-fir, limber pine, and ponderosa pine habitat types with a significant bunch grass component in the understory.

Grass/Forb Species	Native/ Introduced	Pounds PLS per acre at 40 seeds/ft²
'Pryor' Slender wheatgrass	N	12
'Critana' Thickspike wheatgrass	N	12
'Sodar' Streambank wheatgrass	N	11
'Goldar' Bluebunch wheatgrass	N	12
'Sherman' Big bluegrass	N	2
'Manska' Pubescent wheatgrass	I	30
'Covar' Sheep fescue	I	3
'Durar' Hard fescue	I	3
Yellow sweet clover	I	(no more than ½ lb/ac)
Dryland alfalfa varieties	I	(no more than ½ lb/ac)

ZONE 2 is made up of moist, warm sites consisting of moderate environments receiving more effective precipitation than the dry, warm sites. Zone 2 sites are found on north and east-facing slopes at lower elevations, on all aspects at mid-elevations, and on south and west-facing aspects at higher elevations. Sites are dominated by Douglas-fir and ponderosa pine habitat types.

Grass/Forb Species	Native/ Introduced	Pounds PLS per acre at 40 seeds/ft²
'Pryor' Slender wheatgrass	N	12
'Critana' Thickspike wheatgrass	N	12
'Sodar' Streambank wheatgrass	N	11
'Whitmar' Beardless wheatgrass	N	12
'Sherman' Big bluegrass	N	2
'Garnet' Mountain brome	N	22
'Rush' Intermediate wheatgrass	I	22
Nevada bluegrass	I	2
'Covar' Sheep fescue	I	3
'Durar' Hard fescue	I	3
'Paiute' Orchardgrass	I	4
White Dutch, red, or white clover	I	2
Yellow sweet clover	I	(no more than ½ lb/ac)
Alfalfa	I	(no more than ½ lb/ac)

ZONE 3 is made up of moist, cool sites. Zone 3 sites are found predominantly on north and east-facing slopes at mid-elevations and on all aspects at high elevations. Sites are dominated by Douglas-fir with blue huckleberry in the understory along with Grand fir, western cedar, and western hemlock habitat types.

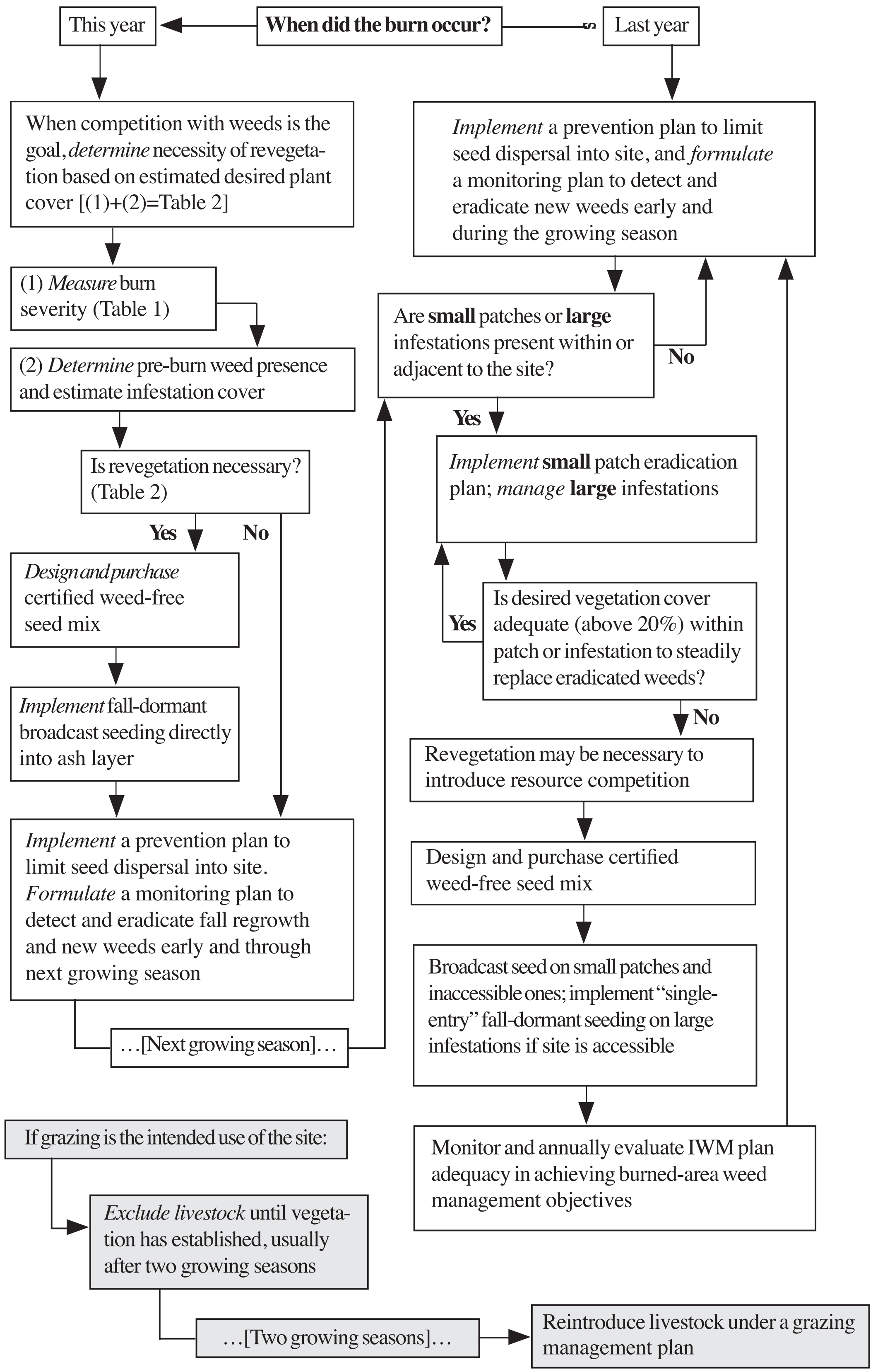
Grass/Forb Species	Native/ Introduced	Pounds PLS per acre at 40 seeds/ft²
'Pryor' Slender wheatgrass	N	12
'Whitmar' Beardless wheatgrass	N	12
'Sherman' Big bluegrass	N	2
Tufted hairgrass	N	1
'Garnet' Mountain brome	N	22
'Rush' Intermediate wheatgrass	I	22
'Paiute' Orchardgrass	I	4
'Covar' Sheep fescue	I	3
'Durar' Hard fescue	I	3
Nevada bluegrass	I	2
Alsike, red, or white clover	I	(no more than ½ lb/ac)
Birdsfoot trefoil	I	(no more than ½ lb/ac)

ZONE 4 is made up of riparian areas including stream bottoms and wet meadows. These sites are subirrigated or wetter for at least a portion of each growing season.

Grass/Forb Species	Native/ Introduced	Pounds PLS per acre at 40 seeds/ft²
'Pryor' Slender wheatgrass	N	12
Basin Wildrye	N	2
Meadow foxtail	I	2
Birdsfoot trefoil	I	(no more than ½ lb/ac)
Alsike clover	I	(no more than ½ lb/ac)

Retrieved December, 2017 from: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/mt/programs/planning/ewpp/?cid=nrcs144p2_056245

DECISION-MAKING PROCESS TO FACILITATE THE FORMULATION OF A BURNED-AREA IWM PLAN



Tax Implications of Farm Business Property Destroyed by Wildfire*

Duane Griffith, *retired Extension Farm Management Specialist, Department of Agricultural Economics and Economics, Montana State University*
Updated by George Haynes, *Agricultural Policy Specialist, Department of Agricultural Economics and Economics, Montana State University, (August 2017)*

Farmers and ranchers must consider many options after a wildfire. The economic implications can be both short term and long term. While a fire can destroy the current year's forage production for livestock or a small grain crop, fires can be beneficial to some types of plant communities in the long run.

The possible remedies and alternative strategies an individual producer might pursue in dealing with short term consequences are beyond the scope of this article. However, there is one aspect to a wildfire that is standard for all producers. Losses inflicted by fire are treated under the same tax rules for all producers.

The IRS refers to these as casualty losses. A casualty occurs when property is damaged, destroyed, or lost due to a sudden, unexpected or unusual event. Fire is identified as such an unusual event, unless the fire was intentionally set or someone else was paid to set the fire. After a fire, you may have a deductible loss or a taxable gain. The end result will depend on several factors, which are discussed in this article.

The calculation of loss depends on whether the property destroyed was farm or personal use property and whether the destruction was complete or partial. First let's cover the simple case of farm property being completely destroyed by fire. To calculate the loss (or gain) for complete destruction of farm property, use the following procedure.

Steps

1. Determine your adjusted basis in the property.
2. Subtract the salvage value, if any.
3. Subtract any insurance or other reimbursement you receive or expect to receive.
4. Result equals the deductible loss or taxable gain.

A casualty loss will result in a taxable gain if insurance proceeds or any other type of reimbursement you receive for the destroyed property exceeds the adjusted basis minus salvage value in the property. The adjusted basis is calculated as original purchase price, plus capitalized improvements, minus all accumulated depreciation, minus other decreases in basis from previous events (a previous partial casualty loss, for example). "Other reimbursements" may include payments received in addition to insurance proceeds. An example may be payments received through a federal agency (FEMA) for a federally declared disaster area. This type of payment is relatively uncommon.

Steps 1 through 4 above are straightforward and easy to follow. Unfortunately, they apply only to farm property that is completely destroyed. If your business property (IRS calls this farm property) is only partially destroyed (damaged) then the procedures are more complicated.

For farm property that is partially destroyed, the calculation of gain or loss follows the same procedure for calculating gain or loss on personal use property, with one exception. Personal use property has deduction limits. These limits do not apply to farm property that is partially destroyed.

Steps to calculate gain or loss on partially destroyed farm property:

1. Determine your adjusted basis (defined on page 2) in the property before the casualty or theft.
2. Determine the decrease in fair market value (FMV) of the property as a result of the casualty or theft.
3. From the smaller of the amounts you determined in (1) and (2), subtract any insurance or other reimbursement you receive or expect to receive.

* This article relies heavily on and borrows text from the annual publication "Farmers Tax Guide," Publication 225 from the Internal Revenue Service. Since tax laws can change often, readers should check with their CPA or the most recent Farmers Tax Guide, Publication 225.

The decrease in FMV is the difference between the property's value immediately before the casualty or theft and its value immediately afterwards. FMV is defined as "the price at which property would change hands between a buyer and a seller, neither having to buy or sell, and both having reasonable knowledge of all necessary facts." While the IRS provides this definition of FMV, it does not provide the exact process to use to arrive at a FMV. As the process is not specified, the procedure you used should be supportable by documentation in the event of an audit.

In the event that insurance proceeds and/or other reimbursements are greater than the adjusted basis minus salvage value of the property destroyed, a taxable gain occurs. If a portion of insurance payments received is for living expenses, do not subtract that portion when determining the amount of loss or gain. You may be required to report insurance payments for living expenses as income.

If you expect to be reimbursed for part or all of your loss, you must subtract the expected reimbursement when calculating your loss. To the best of your ability, you must estimate what the reimbursement will be and reduce your loss even though you may not receive the expected reimbursement until a later tax year. If you later receive less reimbursement than expected, include that difference as a loss with other losses (if any) on the tax return for the year in which you can reasonably expect no more reimbursement.

If you receive more reimbursement than expected after claiming a deduction for the loss, you may have to include the extra reimbursement as income for the year in which it was received. However, if any part of your original deduction did not reduce your tax for the earlier year, do not include that part of the reimbursement in your income. Also, in this instance, you do not refigure your tax for the year you claimed the deduction.

Gains and losses must be calculated for each individual asset. In some instances, you may receive a lump-sum reimbursement for a casualty loss that involved several assets. The lump sum may not be allocated to each of the individual assets when received. In this case, divide the lump-sum reimbursement among the assets using the fair market value of each asset at the time of the loss. This allows you to calculate the gain or loss separately for each asset that has a separate basis.

The IRS provides the following simple example from the Farmer Tax Guide. This example is for property that was only partially destroyed (Table 1).

Adjusted Basis

If your property is only damaged (partially destroyed) then you must adjust the basis in your property for reimbursements received. Your basis must be decreased by any insurance or other reimbursement you receive and any deductible loss claimed on your tax return. The result is your adjusted basis in the property after a partial casualty loss.

The costs of cleaning up or making repairs to damaged property is not a part of the casualty loss but can be deducted as a business expense if the property is farm property and not personal use property. While repairs cannot be included in casualty loss calculations, the amounts spent to restore property after a casualty increase the adjusted basis of the property. The costs of cleaning and repairing can be used as an estimate of the loss of FMV if all of the following conditions are meet:

1. The repairs are actually made.
2. The repairs are necessary to bring the property back to its condition before the casualty.
3. The amount spent for repairs is not excessive.
4. The repairs fix only the damage.
5. The value of the property after the repairs is not, due to the repairs, more than the value of the property before the casualty.

Other incidental expenses due to a casualty, such as an expense for treatment of personal injury, temporary housing, rental car, etc. are not part of the casualty loss. These expenses may be deducted as a business expense if the destroyed property was farm property.

TABLE 1. IRS example from Farmer Tax Guide.

	Tractor	Barn
1. Adjusted basis	$ 3,300	$28,000
2. FMV before fire	$28,000	$55,000
3. FMV after fire	$10,000	$25,000
4. Decrease in FMV (line 2 - line 3)	$18,000	$30,000
5. Loss (lessor of line 1 or line 4)	$ 3,300	$28,000
6. Minus: Insurance	$ 2,100	$26,000
7. Deductible causality loss	$ 1,200	$ 2,000
8. Total loss	$ 3,200	

When to deduct a loss

Causality losses are generally deductible only in the year in which they occur. However, losses in presidentially-declared disaster areas are subject to different rules.

Leased property: If you lease property from someone else, you can deduct a loss on the property in the year your liability for the loss is determined. This is true even if the loss occurred or the liability was paid in a different year. You are not entitled to a deduction until your liability under the lease can be determined with reasonable accuracy. Your liability can be determined when a claim for recovery is settled, adjudicated, or abandoned.

Net operating loss (NOL): If your regular deductions and your casualty or theft loss deductions are more than your income for the tax year, you may have a Net Operating Loss (NOL). An NOL can be carried back or carried forward and deducted from income in other years to gain the tax benefit from the casualty loss.

Proof of loss

To deduct a casualty or theft loss, you must be able to prove that there was a casualty or theft. For a casualty loss, your records should support the amount you claim for the loss and show all of the following information.

1. The type of casualty (car accident, fire, storm, etc.) and when it occurred.
2. That the loss was a direct result of the casualty.
3. That you were the owner of the property or, if you leased the property from someone else, that you were contractually liable to the owner for the damage.
4. Whether a claim for reimbursement exists for which there is a reasonable expectation of recovery.

Figuring a gain

If you receive more insurance or other reimbursement than your adjusted basis in the destroyed or damaged property, you have a gain from the casualty. Generally, gain is reported as income in the year you receive the reimbursement. However, depending on the type of property you receive, you may not have to report your gain. Your gain is figured as follows:

1. The amount you receive, minus
2. Your adjusted basis in the property at the time of the casualty or theft.

Even if the decrease in FMV of your property is smaller than the adjusted basis of your property, use your adjusted basis to figure the gain.

The amount you receive as reimbursement for a loss includes any money plus the value of any property you receive, minus any expenses you have in obtaining reimbursement. It also includes any reimbursement used to pay off a mortgage or other lien on the damaged, destroyed, or stolen property.

You must ordinarily report the gain on destroyed, or other involuntarily converted property if you receive money or unlike property as reimbursement. You can choose to postpone reporting the gain if you purchase replacement property similar or related in service or use to your destroyed, stolen, or other involuntarily converted property within a specific replacement period.

Replacement property

To postpone all the gain, the cost of your replacement property must be at least as much as the reimbursement you receive. Your basis in the new (similar or related in service) property is the same as your adjusted basis in the property it replaced. If you are an owner-user, "similar or related in service or use" means that replacement property must function in the same way as the property it replaces. Examples of property that functions in the same way as the property it replaces are a home that replaces another home, a dairy cow that replaces another dairy cow, and farm land that replaces other farm land. A passenger automobile that replaces a tractor does not qualify. Neither does a breeding cow that replaces a dairy cow. Property you acquire by gift or inheritance does not qualify as replacement property.

Standing crop destroyed by casualty

If a fire, storm or other casualty destroyed your standing crop and you use the insurance money to acquire either another standing crop or a harvested crop, this purchase qualifies as replacement property. The cost of planting and raising a new crop does not qualify as replacement cost for the destroyed crop, unless you use the crop method of accounting. The crop method of accounting is discussed in Chapter 2 of the "Farmers Tax Guide" and is not covered here. If you use the crop method of accounting, the costs of bringing the new crop to the same level of maturity as the destroyed crop qualify as replacement costs to the extent they are incurred during the replacement period.

Timber loss

Standing timber purchased with proceeds from the sale of timber downed as a result of a casualty such as high winds, earthquakes or volcanic eruptions qualifies as replacement property. If the standing timber was purchased within the replacement period, you can postpone reporting the gain.

Replacement period

To postpone reporting your gain, you must buy replacement property that is similar or related in service within a specified period of time, referred to as the replacement period. The replacement period begins on the date your property was damaged, destroyed, stolen, sold or exchanged. The replacement period ends two years after the close of the first tax year in which you realize any part of your gain from the involuntary conversion.

Postponing gain

To postpone your gain, report your choice on your tax return for the year you have the gain. You have a gain in the year you receive insurance proceeds or other reimbursements that result in a gain. You should attach a statement to your return for the year you have the gain. This statement should include all the following information.

1. The date and details of the casualty, theft or other involuntary conversion.
2. The amount of the insurance or other reimbursement received.
3. How you figured the gain.

If you acquire replacement property before filing your return for the year you have the gain, your statement should also include detailed information about all the following items.

1. The replacement property.
2. The amount of gain postponed.
3. The basis adjustment that reflects the postponed gain.
4. Any gain you are reporting as income.

If you intend to buy replacement property after filing your return for the year you realize gain, your statement should also say that you are choosing to replace the property within the required replacement period. You then attach another statement to your return for the year in which you buy the replacement property. Show in this statement detailed information on the replacement property. If you acquire part of your replacement property in one year and part in another year, you must attach a statement to each year's return. Include in the statement detailed information on the replacement property purchased in each tax year.

MONTANA NOXIOUS WEED LIST

Effective: February 2017

PRIORITY 1A These weeds are not present or have a very limited presence in Montana. Management criteria will require eradication if detected, education, and prevention:

(a) Yellow starthistle (*Centaurea solstitialis*)
(b) Dyer's woad (*Isatis tinctoria*)
(c) Common reed (*Phragmites australis* ssp. *australis*)
(d) Medusahead (*Taeniatherum caput-medusae*)

PRIORITY 1B These weeds have limited presence in Montana. Management criteria will require eradication or containment and education:

(a) Knotweed complex (*Polygonum cuspidatum*, *P. sachalinense, P.* × *bohemicum*, *Fallopia japonica*, *F. sachalinensis, F.* × *bohemica, Reynoutria japonica, R. sachalinensis*, and *R.* × *bohemica*)
(b) Purple loosestrife (*Lythrum salicaria*)
(c) Rush skeletonweed (*Chondrilla juncea*)
(d) Scotch broom (*Cytisus scoparius*)
(e) Blueweed (*Echium vulgare*)

PRIORITY 2A These weeds are common in isolated areas of Montana. Management criteria will require eradication or containment where less abundant. Management shall be prioritized by local weed districts:

(a) Tansy ragwort (*Senecio jacobaea, Jacobaea vulgaris*)
(b) Meadow hawkweed complex (*Hieracium caespitosum, H. praealturm, H. floridundum*, and *Pilosella caespitosa*)
(c) Orange hawkweed (*Hieracium aurantiacum, Pilosella aurantiaca*)
(d) Tall buttercup (*Ranunculus acris*)
(e) Perennial pepperweed (*Lepidium latifolium*)
(f) Yellowflag iris (*Iris pseudacorus*)
(g) Eurasian watermilfoil (*Myriophyllum spicatum, Myriophyllum spicatum* x *Myriophyllum sibiricum*)
(h) Flowering rush (*Butomus umbellatus*)
(i) Common buckthorn (*Rhamnus cathartica L.*)

PRIORITY 2B These weeds are abundant in Montana and widespread in many counties. Management criteria will require eradication or containment where less abundant. Management shall be prioritized by local weed districts:

(a) Canada thistle (*Cirsium arvense*)
(b) Field bindweed (*Convolvulus arvensis*)
(c) Leafy spurge (*Euphorbia esula*)
(d) Whitetop (*Cardaria draba, Lepidium draba*)
(e) Russian knapweed (*Acroptilon repens, Rhaponticum repens*)
(f) Spotted knapweed (*Centaurea stoebe, C.maculosa*)
(g) Diffuse knapweed (*Centaurea diffusa*)
(h) Dalmatian toadflax (*Linaria dalmatica*)
(i) St. Johnswort (*Hypericum perforatum*)
(j) Sulfur cinquefoil (*Potentilla recta*)
(k) Common tansy (*Tanacetum vulgare*)
(l) Oxeye daisy (*Leucanthemum vulgare*)
(m) Houndstongue (*Cynoglossum officinale*)
(n) Yellow toadflax (*Linaria vulgaris*)
(o) Saltcedar (*Tamarix* spp.)
(p) Curlyleaf pondweed (*Potamogeton crispus*)
(q) Hoary alyssum (*Berteroa incana*)

PRIORITY 3 Regulated Plants: (NOT MONTANA LISTED NOXIOUS WEEDS)

These regulated plants have the potential to have significant negative impacts. The plant may not be intentionally spread or sold other than as a contaminant in agricultural products. The state recommends research, education and prevention to minimize the spread of the regulated plant.

(a) Cheatgrass (*Bromus tectorum*)
(b) Hydrilla (*Hydrilla verticillata*)
(c) Russian olive (*Elaeagnus angustifolia*)
(d) Brazilian waterweed (*Egeria densa*)
(e) Parrot feather watermilfoil (*Myriophyllum aquaticum* or *M. brasiliense*)

MONTANA STATE UNIVERSITY EXTENSION