1998

EC98-148 Grassland Management With Prescribed Fire

John Ortmann
University of Nebraska - Lincoln

Daniel D. Beran
University of Nebraska - Lincoln

Robert A. Masters
University of Nebraska - Lincoln

James L. Stubbendieck
University of Nebraska - Lincoln, jstubbendieck@unl.edu

Nebraska Cooperative Extension EC 98-148-A

Grassland Management With Prescribed Fire

*John Ortmann and Daniel D. Beran, Graduate Research Assistants, Agronomy;
Robert A. Masters, Associate Professor, Agronomy, and Range Scientist, USDA-ARS; and
James Stubbendieck, Professor (Range Ecology), Agronomy*

This circular provides an overview of the use of fire in grassland management. It describes the history and importance of fire in the grassland ecosystem, how plants respond to fire, and the uses and potential benefits of prescribed fire. It also summarizes fire planning, and legal and safety considerations. And finally, it provides guidance on some special uses of fire.

Figure 1. Fire was one of the primary forces that created and maintained the central grasslands. To a large extent, the fires and resulting grasslands were the deliberate work of Indian land managers.

The History of Fire

Climate, fire, and grazing animals were the principal interacting forces that formed and maintained the Great Plains grasslands. Before European settlement, fires on the Great Plains were set by lightning or Indians. Formerly, it was believed that lightning was the primary ignition source, which would have limited most fires to the growing season when burning conditions would have favored smaller, less intense fires. However, more recent information indicates that Indians burned extensively in all seasons and that most pre-settlement landscapes and vegetation resulted from human activity. Indians used fire for hunting, warfare, signaling, and to reduce insect populations around villages. Many other fires resulted from untended campfires, or were set simply for entertainment. When fires were set to attract wildlife to the resulting fresh, new growth, Indians were deliberately using fire much as land managers do today.

Pre-settlement fire interacted closely with grazing. Not only did wildlife seek out freshly burned areas, but burned areas that were then heavily grazed would tend to burn less intensely or not at all in subsequent fires. Meanwhile, areas that escaped fire would be grazed less, allowing an accumulation of fuel that would promote intense fires later. Grazing and fire existed in a simple but effective rotation in both time and space.

Climate, including such factors as periodic drought, seasonal dryness, and nearly constant winds, permitted fires to burn extensively and helped to suppress woody vegetation that would otherwise have developed.

When Europeans came to the Great Plains, they brought with them the concept of property and attitudes toward fire formed in densely populated Europe or the eastern United States. To them, fire was a scourge that destroyed property, bared the soil, and sometimes killed. With such a tradition, fire was not used as a land management tool, with the notable exception of the Kansas Flint Hills, where fires have been deliberately set since the 1880s. Burning in the Flint Hills was early recognized as a means to increase steer weight gains because it improved grass palatability, quality, and yield, and halted woody plant expansion.

The role of fire in manipulating plant communities was not critically examined until the 1960s. Fire was reintroduced in the southeastern and northwestern United States to enhance forest regeneration and wildlife habitat. Interest in burning as a land management practice has since increased because other management practices, such as herbicide application or cutting, can be environmentally risky, ineffective, or too expensive. Also, it was recognized that much of the productivity losses of North American grasslands were due to a combination of improper grazing and fire suppression.

Wildfire vs. Prescribed Fire

Wildfires and prescribed fires differ in most respects. Wildfires are unplanned and usually due to lightning, human negligence or malice. Wildfires usually happen during extended dry periods when soil moisture levels are low and plants are severely stressed, or when desirable plants are growing. Such poorly timed fires can result in reduced forage yields and other undesirable effects. In contrast, prescribed fires are planned and conducted at the proper time, and in a safe manner, to meet specific management objectives. Typically, desirable plants are dormant, soil moisture is sufficient to support plant growth after the fire, and favorable environmental conditions ensure predictable fire behavior and simplify control.

Plant Adaptations to Fire

How a plant responds to fire depends on the height above ground of its growing points, a function of plant maturity and plant-growth characteristics. If growing points are above the soil surface, within reach of lethal temperatures, the plant likely will be damaged or killed. Perennial grasses that tolerate fire when dormant have growing points at or below the soil surface. Generally, a fire will raise the temperature of the upper 1/4 inch or so of soil only momentarily.

Annual grasses and broadleaf plants are damaged when burned during active growth. Biennials also can be damaged during intense fires if their growing points are raised. Perennial plants differ in their responses to burning based on reproductive strategies and position of the growing points. Perennial grasses are damaged if stems are elongated. Timing of fires can be used to favor desirable grasses and suppress undesirable grasses. Plants that reproduce solely by seed, such as eastern redcedar *(Juniperus virginiana L.)*, can be killed by fire if their growing points at the twig tips are exposed to lethal temperatures. In contrast, perennial plants that can reproduce vegetatively from subsurface buds are usually only top killed. These plants, such as smooth sumac *(Rhus glabra L.)*, initiate new shoots after fire.

Figure 2. Plants respond differently to fire depending on where their new growth occurs. Eastern redcedars grow from the twig tips and were killed when this site was burned about a month earlier. Native grasses initially grow from their bases and were unharmed.

Woody plants resist heat damage when their growing points are above the flames. Their bark also protects vascular tissue. The protective quality of bark depends on its thickness, composition, fissuring, and moisture content. These factors affect the bark's ability to absorb and transmit heat. Since bark is the only protection for vascular tissue, young, thin-barked saplings are not as heat resistant as older plants. In addition, moist bark absorbs, holds, and transmits heat more than dry bark.

Factors That Influence Fire Behavior

The primary fire variables to be considered are amount of fine fuels (dead grass) present, the weather conditions before and at the time of the fire, and the fire objectives.

Generally, the more fuel present, the better. Adequate fuel not only assures that the objectives can be met, but if a surplus is available, the site can be burned under a wider range of weather conditions without jeopardizing the objectives. "Adequate" fuel varies by site and situation, but some objectives require relatively more fuel than others. For example, removing eastern redcedar will normally require more fuel than a fire designed primarily to suppress cool-season grasses. However, weather also will influence results and should be considered by the manager. At a given fuel level, relatively warmer and drier conditions will provide better performance. If the combination of fuel and weather is unsuitable, the manager should be prepared to postpone the fire until the weather is better. Since all fires involve expense, effort, and some risk, they should not be conducted without a reasonable chance of success.

Vegetation considered as fuel is classified by volatility. High volatility fuels have large amounts of compounds, such as fats, waxes, or oils, that are highly flammable and can produce firebrands or windborne flaming debris. Examples of high volatility fuels are eastern redcedar and ponderosa pine *(Pinus ponderosa Laws)*. Despite their explosive nature, high volatility fuels can be burned safely with proper precautions. Low volatility fuels, such as most grasses and hardwood trees, contain small amounts of such compounds and are not as flammable. These fuels can be burned safely within a wider range of environmental conditions than high volatility fuels.

Benefits of Prescribed Fire

Prescribed fire is not a "magic bullet" that alone will erase past management failures or make up for improper management in the future. However, prescribed fire can yield many benefits if it is used with other sound management practices. In grasslands, prescribed fire can increase grass nutritive quality, palatability, availability, and yield, reduce hazardous fuels, suppress unwanted plants, and improve wildlife habitat. Grass quality, palatability, and availability are improved because the fire removes dead plant material and improves access to new growth. If soil moisture is adequate, grass yields increase because baring and darkening the soil surface allows it to warm more quickly and stimulate earlier growth, and because competing weeds are suppressed.

When Not to Burn

The use of prescribed fire on sandy soils, during the wrong environmental conditions, or at the wrong time can be dangerous and fail to achieve management objectives. Fire should be used with caution on sandy soils because wind erosion is possible when ground cover is removed. Although these sites were burned in pre-settlement times, there is little research on the deliberate use of fire on them and management risks are great. Heavier soils are not as prone to wind erosion. Slopes greater than 30 percent should be burned with caution because of the danger of water erosion. In some cases, however, as when an eastern redcedar invasion must be controlled, the risk of not using fire may outweigh the risk of erosion. Careful timing of the fire can minimize the erosion risk.

Burning during the wrong environmental conditions is dangerous and can harm desirable plants. Plant growth may be reduced if soil moisture is low at the time of the fire. When soil moisture is low, the risk of soil erosion increases because ground cover is removed and plant regrowth is delayed. Burning when relative humidity is less than 25 percent, air temperature is above 80^{o}F, and wind speed is more than 15 mph causes intense, possibly dangerous fire behavior. On sites with low fine-fuel loads humidity higher than 60 percent, temperatures less than 40^{o} F, and winds less than 5 mph will result in patchy, incomplete burns that may fail to achieve management objectives. In most cases, fires should not be set unless winds are at least 5 mph from a consistent direction. This allows the fire to be controlled and directed. Light and variable winds will cause the fire's direction to shift erratically, making control difficult.

Improper fire timing can reduce plant productivity. If the goal is to increase warm-season tallgrass growth, the burn should be just before or during growth initiation, from mid-April to early May. Yields will be reduced if these grasses are burned when actively growing. If the burn is too early, cool-season grasses will increase and deplete soil water and nutrients before warm-season grasses begin growth. Generally, burning does not benefit shortgrasses, such as blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.] or buffalograss [*Buchloe dactyloides* (Nutt.) Englem.], because of low rainfall in their native ranges.

Planning a Prescribed Fire

Planning is essential to safe burning and should be done well in advance of the proposed burn date. The plan should cover objectives, what areas to burn, pre-fire management practices needed to meet objectives, how to conduct the fire, and any post-fire management practices.

The objectives should be realistic and may include increasing grass forage or seed yield and quality, improving wildlife habitat, weed suppression, or others. Prescribed fire is not a cure-all for past management mistakes. For example, a severely overgrazed native pasture now dominated by cool-season grasses such as Kentucky bluegrass (*Poa pratensis* L.) or smooth bromegrass (*Bromus inermis* Leyss.), will not provide greatly improved yields of warm-season grasses, such as big bluestem (*Andropogon gerardii* Vitman *var. gerardii* Vitman), switchgrass (*Panicum virgatum* L.), or indiangrass [*Sorghastrum nutans* (L.) Nash], following a single fire. To achieve objectives on degraded pasture, resting, or chemical or mechanical treatments may be needed before and after the fire.

Pre-fire treatments may be needed to accumulate adequate fine fuel to carry fire and meet management objectives. For example, on warm-season tallgrass-dominated pastures, grazing may need to be deferred from mid- or late summer until the burn date the following spring. In drier areas, dominated by mid-grasses including sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.] and little bluestem [*Schizachyrium scoparium* (Michx.) Nash], pastures may need to be deferred for an entire growing season. The importance of having adequate fine fuel to carry a fire cannot be overemphasized, especially when woody plant control is the objective.

Post-burn management also is critical. Benefits will be lost if recovering vegetation is abused. After the fire, delay grazing until considerable grass growth has occurred. Grazing too soon will decrease grass vigor and yield, ultimately decreasing livestock carrying capacity. Entire pastures should be burned if livestock grazing is the primary use. If only part of a pasture is burned, the burned portion will be grazed more than the unburned portion, resulting in possible damage to the burned area and under use of the unburned area.

Legal and Safety Considerations

Under Nebraska law, which recognizes the benefits of prescribed fire for range management, an open-burning permit must be obtained from the fire chief of the district in which the property to be burned is located. To obtain the permit, a prescribed-burning plan must be submitted. It must list who is responsible, the objectives, how the fire will be confined, equipment needs, smoke management, acceptable weather conditions, vegetation characteristics, and any local requirements. The plan also must include a map of the site and its surroundings that points out natural and created firebreaks that will be used to confine the fire.

In effect, the plan becomes part of the permit. If the plan is not followed and problems result, the permit holder has in essence invalidated the permit and increased his or her legal exposure. It is crucial to carefully follow the fire plan. An acceptable plan can be written by filling out the "Prescribed Burning Checklist" section of Extension Circular EC 90-121, *Conducting a Prescribed Burn*.

Safety is a prime concern when burning. As with any technology, the use of fire involves some risk. To minimize risk, the fire must be planned in detail and supervised by a person experienced with burning similar vegetation. Fire crew members should be competent and reliable people capable of taking orders. Prescribed burning is physically demanding, so workers must be in good physical condition.

Special Uses of Prescribed Fire

Conservation Reserve Program Lands

Prescribed burns on Conservation Reserve Program (CRP) lands planted to warm-season grasses, especially switchgrass, can be unusually intense because of the high fuel loadings. Such fires can produce flame heights in excess of 50 feet and headfires can advance faster than the wind speed.

With proper planning, however, burning CRP sites actually may be safer than burning many pasture or rangeland sites. There are several reasons for this. First, many CRP sites already are all or partially bounded by effective firebreaks, such as roads, tilled fields, or other non-flammable areas. Second, as former cultivated fields, the edges of CRP sites are accessible to equipment, allowing firebreaks to be mowed or tilled before the burn date. Also, this access allows the use of mechanical water pumpers on the firelines for suppression or to lay down wetlines. Finally, the surplus of fuel means that CRP sites can be burned under cool, damp conditions that will reduce fire intensity while still achieving management objectives.

Figure 3. Burning CRP sites often is simple despite high fine-fuel loads and fire intensity because the sites usually are all or partially enclosed by existing firebreaks, such as roads, tilled fields, or relatively non-flammable headlands.

More detailed information on burning CRP sites is available in *Conducting a Prescribed Burn on Warm-Season Grass CRP Sites*, NebFact 96-268.

Eastern Redcedar Management

Eastern redcedar trees are invading many Nebraska grasslands. These infestations reduce forage production and will only worsen with time. The periodic use of prescribed fire is essential in eastern redcedar management, both to inexpensively reduce initial tree numbers and to prevent reinfestation. If eastern redcedar management is the primary objective, some variations in the usual practices may be desirable. For example, an earlier burn date, around April 1, may provide better control than the May 1 date generally recommended for warm-season grass management because eastern redcedar foliage is drier and more flammable before spring growth begins. Also, use of the warmest, driest conditions consistent with safety and fire control will improve effectiveness. This is especially important in grazed pastures where fuel loads are low.

More detailed information on integrating prescribed fire with other control measures is available in *Management of Eastern Redcedar on Grasslands*, NebGuide G96-1308.

Smooth Sumac Management

Smooth sumac invades many grasslands, reducing forage production and accessibility under the dense sumac canopy. Fire alone is ineffective against smooth sumac because, while the aerial stems may be top-killed, the plant will resprout from root buds. In recent Nebraska research, 2,4-D ester at 2 lbs. active ingredient per acre applied to the foliage provided nearly complete control. However, fire can play a role in smooth-sumac management. Reducing canopy height may ease herbicide application. In addition, fire will help rejuvenate warm-season grasses that have declined in vigor and productivity under the canopy.

More detailed information on smooth sumac control is available in *Management of Smooth Sumac on Grasslands*, NebGuide G97-1319.

Landscape-Scale Fire

Traditionally, managers have used prescribed fire on individual pastures. This is inefficient and risky in large blocks of continuous rangeland where the danger of escape is high and rugged terrain prevents the preparation of firebreaks. Fires on such sites usually must be controlled by hand suppression alone at the fence lines. This is labor-intensive, time-consuming, and physically exhausting.

An alternative approach is to burn several pastures at once, ideally arranged so they form a landscape unit all or partially bounded by effective pre-existing firebreaks. These may be roads or trails, green canyon bottoms, tilled land, watercourses, corridors of relatively non-flammable deciduous growth along draws, or even severely overgrazed pastures bordering the area to be burned.

Figures 4 and 5. Burning single management units in continuous fuel often requires extensive hand suppression along firelines and an increased risk of escape. Burning multiple pastures as a single unit, however, often allows the use of existing firebreaks and greatly improves safety while reducing the labor and time required.

The advantages of this approach include substantial savings in time and labor, vastly improved safety and reduced risk of escapes, and often the ability to patrol the fire boundaries with vehicles, including mechanized water pumpers. Landscape-scale fires are particularly useful for eastern redcedar control because the added safety counteracts the risk of burning during ideal warm and dry conditions. Also, eastern redcedar is a high volatility fuel capable of producing airborne flaming firebrands. Effective firebreaks can reduce the risk of firebrands blowing outside the fire boundary. Additionally, boundary areas can be ignited earlier in the day when conditions are cooler and damper to further reduce the risks of escapes and firebrand lofting. By the time fire conditions have become more intense later in the day, the fire will have retreated to the center of the landscape unit where risks are minimized. The technique may be most applicable in the Loess Hills region, where eastern redcedar is a particular problem, because the highly dissected topography provides many natural landscape features that can be used as firebreaks.

The primary disadvantage of landscape-scale fires is that more than one landowner or manager is likely to be involved. All must agree on whether a fire is needed and the details of conducting it. If one pasture in the landscape unit must not be burned, many of the advantages cited previously will be lost. On the other hand, the participation of multiple landowners and managers should assure adequate labor and equipment.

Fire and Cool-Season Grasses

Most research and recommendations on prescribed fire relate to warm-season grasses. Much less is known about the use of fire on cool-season grasses. However, a manager may have sound reasons to consider fire in this vegetation type. These may include many of the same objectives associated with burning warm-season grasses, such as woody plant control or thatch removal. Also, grazing distribution and uniformity may be improved by burning cool-season bunch grasses such as tall wheatgrass [Elytrigia elongata (Host) Nevski], which accumulates dead stems that block access to new growth.

One obvious difference between burning cool-season vs. warm-season grasses is fire date. Fires should be conducted just before or just as the grasses begin spring growth. For cool-season grasses this could be as much as six to eight weeks earlier than for warm-season grasses.

The situation is more complex when fire is considered on rangelands or pastures that have both significant cool- and warm-season components. Fires conducted early will encourage the cool-season grasses at the expense of the warm-season grasses. Those conducted later will have the opposite effect. While suppressing cool-season grasses often is desirable, a manager may have come to rely on early production from the cool-season component. Much of this production will be lost with a late fire. Total production also may be temporarily reduced if the warm-season component is too sparse or weakened to take immediate advantage of the reduction in competition.

The use of fire on such mixed stands should be carefully considered. Ideally, fire should be incorporated in a long-term pasture-management plan designed to maintain or increase future production, while short-term losses are minimized and planned for.

Fire and Wildlife Habitat Management

Burning can benefit many wildlife species by increasing habitat diversity, and the nutritive quality, availability, and yield of browse, seeds, and forage. A common misconception is that many animals are killed by fire. Animals usually escape by running or flying away, going below ground, or moving to unburned islands of vegetation. The primary fire effect on wildlife is habitat alteration, not mortality.

There is increased use of planted grasslands primarily intended for wildlife habitat, including many CRP sites. If improvement or maintenance of wildlife habitat is the objective in using fire, some variations in practices recommended elsewhere in this publication may be in order. For example, many upland birds, including game birds, enter their peak nesting period in May. Fires conducted in early April will avoid most nest destruction. Also, while entire pastures should be burned when grazing is the primary use, habitat sites can be divided so that only a half or third is burned in a given year. This will provide a refuge for animals excluded from the burned area, and increase habitat diversity because burned and unburned areas will develop different canopy structures, litter accumulations, and to some extent, plant species.

EC148

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert C. Dickey, Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.