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OKLAHOMA COOPERATIVE EXTENSION SERVICE

Fire Prescriptions for Maintenance and Restoration of Native Plant Communities

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Introduction

Four conditions are necessary for fire to assume ecological importance: (1) an accumulation of organic matter, i.e. fuel either herbaceous or woody, sufficient enough to burn; (2) dry weather conditions to render the material combustible; (3) a landscape conducive to the spread of fire; and (4) a source of ignition. The only two important sources of ignition are humans and lightning. Historically, Native Americans had a much greater role in establishing fire on the landscape than did lightning.

The purpose of using prescribed fire (of which we have control) is to reestablish one of the three key ecosystem drivers on the landscape. The other two drivers are herbivory (of which we have control) and climate (of which we have no control). One goal of all management plans should be to restore ecosystem process such as photosynthesis and decomposition. These processes facilitate energy flow, nutrient cycling, water cycling, etc. Research has shown that there is no substitute for fire in restoring ecosystems.

A fire prescription is a set of conditions under which a fire will be set to meet land management objectives. It is based on scientific research and experience. The purpose of this fact sheet is to provide recommendations for developing fire prescriptions. Specific recommendations must be customized for the particular piece of land in question. There are many possible fire prescriptions and vegetation responses.

Many factors affect vegetation response (i.e. habitat) after a prescribed fire or wildfire. These include weather, stage of plant succession, fuel load, topography, soil type, and previous management. In order to select a starting point for fire prescription development, select the dominant native vegetation type on the land in question (e.g. tallgrass prairie, oak-pine forest, etc.). There are 15 major native vegetation types in Oklahoma, based on the Duck and Fletcher survey map of 1943. This and other useful information are included in the ***Field Guide to Oklahoma Plants*** available from Oklahoma State University's Rangeland Ecology and Management Program at 405.744.6421. Another essential reference for establishing vegetation management goals is an ***Ecological Site Guide*** available from Natural Resources Conservation Service (NRCS) offices located throughout Oklahoma. An ecological site guide lists the plants and approximate proportions plus other important information relevant to the site.

Fire Prescriptions

The most frequently asked question is "Under what conditions should I burn?" First, determine your management goals and objectives. Then develop a fire prescription based on the unit of land in question. The following range of prescription variables have been used successfully in Oklahoma and surrounding states for different objectives (Table 1). These prescriptions may require specialized personnel, tactics, training, equipment, and firebreaks. Execution of some fire prescriptions requires specialized training and is inherently more risky than "normal" prescriptions (Table 2). We suggest consultation with a fire management specialist to develop a customized fire prescription that will meet your objectives.

General Guidelines

Rule 1. For those in the process of learning to burn or with limited experience, use the **60:40 Rule**. The 60:40 rule states that you burn with an air temperature of less than 60°F, a relative humidity greater than 40%, and a wind speed of 5-15 mph measured at 6 feet above the surface of the ground.

Rule 2. For those concerned about weather conditions changing below their comfort zone or out of the prescription, use the **Rule of Halves**. This rule is used in the field to predict changes in fire behavior. When the air temperature increases by 20°F, the relative humidity decreases by 50%. For example, if the air temperature changes

Table 1. Potential fire prescription variation for conducting a prescribed fire.

Prescription Variable	Range
Temperature in Degrees Fahrenheit	30 – 110°F
Relative Humidity in Percent	10 – 80%
Wind Speed in Miles Per Hour	4* – 25 mph
Season of Burn	Winter, Spring, Summer, or Fall

*Note: Caution! Light winds are usually variable in direction; during inversion conditions (e,g., nighttime with clear skies) they will tend to flow toward areas of lower elevation (gravitational drainage flow).

For purposes of fire prescription and fire behavior, it is important to use wind information at midflame height. Wind speeds and directions can be measured at a variety of heights, the standard height being 10-m (33 ft).

In Oklahoma, current wind speeds and directions at 10-m height for over 115 Mesonet sites can be obtained from the Oklahoma AgWeather site (http://agweather.mesonet.org). Wind speeds at 2-m (6.5 ft) height are also available for most of the Mesonet sites. To reduce these 10-m or 2-m Mesonet-measured or other "officially measured" speeds to midflame height, follow the guidelines provided. Of course, one can always take onsite measurements using a hand-held anemometer (with no wind speed reduction needed).

For a 2-m tower in:

1. In grassy areas - reduce the wind speed by 50%
2. In shrub/brush areas - reduce the wind speed by 60%
3. In forest understories - reduce the wind speed by 70%

For a 10-m tower in:

1. In grassy areas - reduce the wind speed by 20%
2. In shrub/brush areas - reduce the wind speed by 30%
3. In forest understories - reduce the wind speed by 50%

Preparing before starting a prescribed burn is the easiest way to stay safe and keep the burn under control.

Table 2. Fire Prescription Interactions for Maintenance and Restoration.

Objective and Prescription Variable ↓	Degraded Phase	Restoration Phase	Maintenance Phase
		Manipulative intervention	Periodic fire required, as well as, other normal ecological processes
Escape Risk	High	Moderate	Low
Complexity of Burn	High	High to Moderate	Low
Wildlife Habitat Water Quality/Quantity Livestock Habitat	Poor	Poor to Moderate	Good
Forest	• Overstory of Cedar	• Midstory Cedar	• Understory or No Cedar
Fire Type*	• Fire type D or wildfire	• Fire type C, F, G	• Fire type A, B, C, E
Fuel Type/Flammability	• Cedar/Volatile	• Cedar, leaf litter/Volatile	• Leaf litter/Non-Volatile
Weather Conditions	• High temp & winds, Low RH	• High temp & winds, Low RH	• Low temp & winds, High RH
Prairie & Shrublands	• Cedars > 20' tall • > 250 trees/acre	• Cedars 6' to 20' tall • 250 trees/acre	• No Cedar/Cedar < 6' tall • < 250 trees/acre
Fire Type*	• Fire type D or wildfire	• Fire type C, F, G	• Fire type A, B, C, E
Fuel Type/Flammability	• Cedar/Volatile	• Cedar, grass, shrub/Volatile	• Grass, shrub/Non-Volatile
Weather Conditions	• High temp & winds, Low RH	• High temp & winds, Low RH	• Low temp & winds, High RH
Riparian Zone Habitats	• Cedars > 20' tall • > 250 trees/acre	• Cedars 6' to 20' tall • 250 trees/acre	• No Cedar/Cedar < 6' tall • < 250 trees/acre
Fire Type*	• None	• None	• Fire type A, B
Fuel Type/Flammability	• Cedar/Volatile	• Cedar, leaf litter, grass/Volatile	• Grass, leaf litter/ Non-Volatile
Weather Conditions	• None without loss of habitat	• None without loss of habitat	• Low temp & winds, High RH

* Fire types from Eastern Redcedar Control and Management-BMP to Restore Oklahoma's Ecosystems F-2876

from 60°F with 40% humidity to 80°F, the relative humidity will change from 40% to 20%. A fire that can be conducted safely at 40% relative humidity may pose a safety risk at 20%.

Rule 3. In most cases, do not burn if there is a forecasted frontal passage or wind shift within 12 hours.

Rule 4. In general, the width of firebreak on the down wind side of the area to be burned should be 10 times the height of flammable vegetation. Firebreaks are usually a combination of bare ground, mowed strips, and backfired strips. If the firebreak is insufficient, you may experience a fire escape.

Rule 5. If the conditions are not right, including all parts of the prescription (adequate personnel, equipment, weather conditions, etc.), do not start the fire. Wait until everything is right.

Rule 6. If the fire is not going well, put it out.

Rule 7. Do not leave the fire until it is completely out, that is no smoke for at least one hour.

Special Considerations

Brush Piles

Trees and brush should never be cut, dozed, and piled prior to a prescribed burn. This will only complicate the burn and increase spotfire chances. Research has shown that brush piles can cause spotfires up to 500 feet down wind. You may also need to doze or cut trees around the boundary of the burn unit. This will make the burn safer. Let downed trees dry and burn them individually before conducting the fire. If piling is absolutely necessary, then push the piles 300 feet into the burn unit. Keep piles small.

There are also some economic benefits to not cutting down trees until after you burn. If you burn first, the fire should kill many of the cedars depending upon height and fuel load. Then you can let a cedar cutter cut only the trees that did not crown or brownout. This will reduce time and cost for cedar control.

The best time to burn brush piles is after the prescribed fire. Burn while the area is black or let the grass green-up. We have found that the safest time to burn brush piles is May and June. During this time most grass is green and will not burn. Care should be exercised when burning brush piles that have been ungrazed or lightly grazed. Have suppression equipment available on site anytime you burn.

Safety Concerns

Burns with higher temperatures and lower humidity are for experienced fire bosses and crews. The following figures (Figures 1 and 2) show the results of 99 burns conducted by an experienced OSU burn crew between 1996 and 2002. Notice that spotfires do occur under certain conditions. The concern is how large the spotfire gets before it can be stopped. This will depend upon fuel load, wind speed, crew size, crew experience, dependability of equipment, and how soon the spotfire is discovered. Figure 1 shows that only two spotfires occurred out of 53 fires conducted with humidity over 40% (60:40 rule). Nineteen spotfires occurred out of 46 fires conducted with humidity less than 40%. This demonstrates a definite threshold for spotfire occurrence. Spotfires

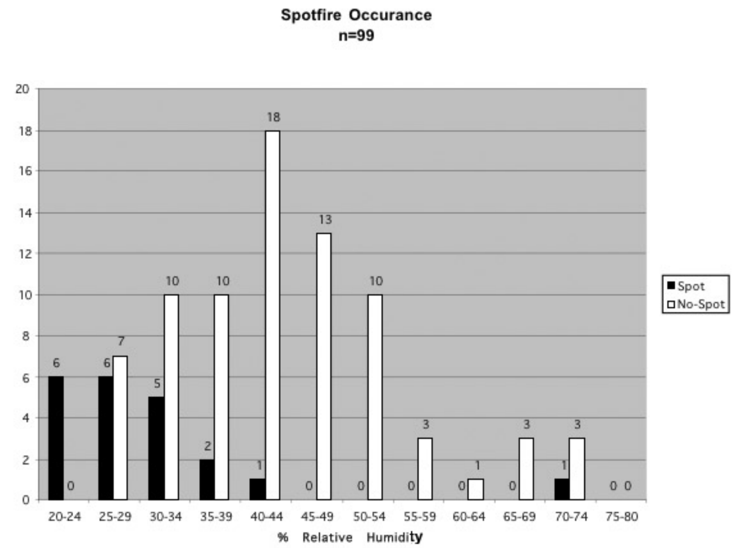

Figure 1. Probability of a spotfire occurring while burning with different humidities.

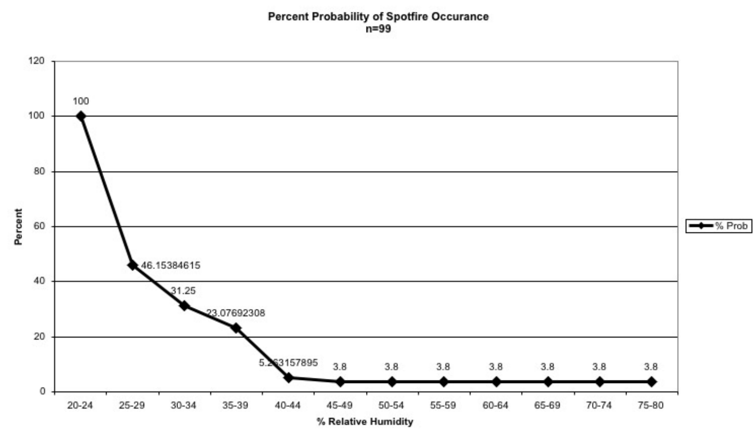

Figure 2. The probability of spotfires as a function of relative humidity, based on 99 prescribed fires conducted across Oklahoma from 1996-2002.

are only a problem if you are unprepared to stop them. There is no evidence that burning under normal prescriptions pose any danger for starting a wildfire that cannot be controlled. "Normal" fire prescriptions do not support wildfire.

If a prescribed fire is conducted with relative humidity under 25%, there is a 100% probability of a spotfire occurring. There is only a 46% chance of a spotfire when the humidity is between 25 and 29% (Figure 2). This data does not infer that you should not burn with humidity under 40%, but suggests that this is one many decisions that must be made when planning a prescribed burn. There are areas in western Oklahoma that will not burn when the humidity is over 40%, but there are also areas that can be burned more safely with humidity over 40%. Figure 2 also shows that burning with humidity less that 40% should be practiced only by those with experience. Before you light any fire ask yourself, "Can the fire crew control this fire if it escapes?"

One factor that can increase the safety margin is that heavy fuel loads override high humidity. Thus you can burn with high humidity and accomplish the same objectives, e.g. scorching woody plants, as burning with low humidities and light fuels. High humidity usually reduces the risk of the fire escaping or having spotfires.

Another safety consideration and potential objective is the role of woody fuels in a fire and how to assess their potential for combustion. Woody fuels can be classified as dead or live. Live fuels typically exceed 100% moisture on a dry weight basis (wet weight, minus dry weight, divided by dry weight, times 100, equals percent fuel moisture). Determine the percent fuel moisture on a dry weight basis within the dead woody fuel category (10 hour time lag fuel) and herbaceous/woody fuel category (1 hour time lag fuel) (Table 3). Time lag fuels refer to the time necessary for fuel (dead woody or herbaceous) to lose approximately 63% of the difference between its initial moisture content and its equilibrium moisture content. Woody fuel samples are taken from standing dead trees or shrubs and must not be lying on the ground. Moisture in woody fuel samples is measured in the field by a moisture meter or weighed in the field and then dried in an oven and weighed again. Herbaceous fuel is weighed in the same manner and must be standing erect. The categories for time lag fuels are listed in Table 4.

Table 4. Time lag fuels.

Fuel Size (inches in diameter)	Time Lag (hours)
0-0.24 herbaceous or woody	1
0.25-1.0 woody	10
1.0-3.0 woody	100
>3.0 woody	1,000

The threshold moisture at which fine fuels (1-hour time lag) will or will not burn in sunlight is 30 to 40%. Below 20% fine fuel moisture has relatively little effect on prescription objectives in comparison to wind speed. The preferred range of fine fuel moisture for prescribed fire is from 7 to 20%. Other threshold fine fuel moisture thresholds are 5%, 7 to 8%, and 11%. Below 5% fine fuel moisture (relative humidity less than 20%) spotfires are certain, whereas spotfires are rare when fine fuel moisture is above 11% (relative humidity 65%). Fine fuel moisture of 7 to 8% corresponds to a relatively humidity of 40%, which is the minimum relatively humidity at which firebrands usually cease to be a problem in dry grass.

Following a rain, fine fuels such as dead grass reach 80% of their equilibrium moisture content with ambient weather within 1 hour. However, small dead woody limbs 2 inches in diameter may require up to four days at a constant relative humidity and temperature to reach equilibrium, and logs (1,000 hour time lag fuel) may require weeks or months. For example, in the 1988 Yellowstone fire, 1,000 hour fuel moisture was less than 5%, thus setting the stage for a very intense fire with extreme fire behavior.

Prescribed fire will spread well when 10-hour time lag fuel moisture is between 6 and 15%. This fuel size will burn up rabidly at 6% fuel moisture and not burn at 15% fuel moisture. Fuel moisture both in and adjacent to a prescribed fire is important for both meeting objectives and safety. If fuel moisture exceeds 30 to 40% in duff or fine fuels (grass) or 15% in 10-hour time lag fuels, there is minimal danger from firebands moving downwind to start a spotfire.

Smoke Management

Burning on days that have good smoke dispersion can reduce smoke effects. Before beginning a prescribed fire, the effects of smoke downwind must be considered. Burning so that smoke disperses away from sensitive areas (residential areas, hospitals, highways, and airports) must be considered in the burn plan. Burning should be conducted according to smoke management guidelines and regulations. Burning during times of high air pollution should be avoided and burning during the nighttime should be done with caution. Temperature inversions can trap smoke near the ground and cause serious visibility problems. Completing prescribed fire early in the day reduces the amount of smoke that may be trapped in a nighttime thermal inversion. If smoke is a problem, consider burning smaller units or backfiring. If a unit has not been burned for many years, relatively more smoke will be produced the first time it is burned. Research has shown that wildfires contribute much more air pollution than prescribed fires. See the Oklahoma Mesonet web site on Smoke Dispersion Model at http://agweather.mesonet.org/weather/.

Woody Plant Response to Fire Frequency and Fire Season

To control woody plants, burning following bud break and full leaf-out is the most effective time. It is important to know how the woody plant will respond after the fire. Most woody plants will resprout but some like eastern redcedar will not resprout if the top growth is killed. Woody plant's tolerance to fire depends on many factors and species-specific information should be obtained as part of the fire prescription process. A good rule-of-thumb is that the thicker the bark the more resistant the species is to fire. However, the most important element in woody plant response is fire frequency, not the time of year (season). In general, fires with a frequency of three years or less will cause resprouting woody plants to decline. Fires with a frequency of four years or longer will allow woody plants to increase in canopy cover and height.

Herbaceous Plant Response to Fire Frequency and Fire Season

Historical Overview

For many years, recommendations for burning tallgrass prairie have been very specific and time sensitive to a calendar date and season based on research studies in northern Kansas. However, the research behind these recommendations has been extended beyond its underlying scientific basis and the results have not been found to be repeatable, a test of scientific merit. The Kansas recommendations were based on research taken from only two replicates of ungrazed small plots (the historical Aldous plots). Other data used for these recommendations were collected from inside cages that were ungrazed and not replicated. These studies did not validate the recommendation that burning should only be done in late spring for the best cattle production. In fact, other studies on season of fire on tallgrass prairie have demonstrated that forage production varies from year to year based on weather and is not predictable by following calendar dates or the

Table 3. Influence of Relative Humidity and Fuel Moisture on Prescribed Burning and Wildfire

R.H (%)	1-Hour F.M. (%)	10-Hour F.M. (%)	Prescribed burning Containment problems, fire spread, smoke	Wildfire Relative ease of chance ignition and spotting, general burning conditions
>60	>20	>15	Fire may not spread in fine fuels, slow spread rate, with skips likely; smoldering combustion in litter will produce heavy smoke.	Very little ignition; some spotting may occur with winds above 9 mph.
45-60	15-19	12-15	Containment not usually a problem; upper limit for continuous flame front in dead fine fuels. Suitable for herbaceous fuel reduction. Smoldering combustion in heavy litter will produce heavy smoke.	Low ignition hazard—campfires become dangerous; glowing brands cause ignition when relative humidity < 50%.
30-45	11-14	10-12	Lower limit for containment. Backfires spread continuously except in very light fine fuels. Suitable for brush control and burning volatile fuels with wide fuel breaks. Less smoldering combustion in litter and generally good smoke lift.	Medium ignitability—matches become dangerous; occasional crowning, spotting caused by gusty winds; moderate burning conditions.
15-30	5-7	5-7	Containment difficult. Backfire is intense and may bridge narrow fuel breaks. Suitable only if very wide fuel breaks are in place. Not suited for burning volatile fuels.	Quick ignition, rapid buildup, extensive crowning; any increase in wind causes increased spotting, crowning, loss of control; fire moves up bark of trees igniting aerial fuels; long distance spotting in pine stands; dangerous burning conditions.
<15	<5	<5	Spotting likely. Unsuitable conditions for prescribed burning.	All sources of ignition dangerous; aggressive burning, spot fires occur often and spread rapidly, extreme fire behavior probably; critical burning conditions.

phenology of plants for timing of fire (see OSU Fact Sheet F-2877, Fire Effects in Oklahoma). Tallgrass prairie response to fire is highly variable due to the amount and distribution of precipitation, air temperature, soil type, previous history of grazing and fire (and lack thereof), presence of invasive plants, and current management. Other concerns related to these Kansas recommendations relate to the diversity of prairie plants and wildlife. For example, research has shown that burning large tracts of land in late spring is detrimental to ground nesting birds, such as the Greater Prairie Chicken and Bobwhite Quail, other prairie birds, and plant diversity.

Contemporary Research and Recommendations

Research has shown that varying the season of burn will benefit beef cattle and wildlife, and help control native invasive species such as eastern redcedar. Recent research has shown that fire applied in patches during both the growing and dormant seasons when combined with cattle grazing will slow the spread of sericea lespedeza, a non-native and invasive noxious weed. Varying season can cause swings in species composition based on whether the plants are cool (C3) or warm season (C4) grasses or forbs (herbaceous plants with broad leaves). Grasses and forbs can be perennials (grasses and forbs that live for more than 2 years), biennials (forbs that live for 2 years), or annuals (grasses and forbs that grow from seed each year). Cool season perennial grasses are more susceptible to burning during the late winter and early spring. If management objectives are to increase cool season grasses then burning in seasons other than late winter/early spring will yield the best results. For example, burning in September is just before cool season grasses begin there growth period. Warm season perennial grasses are actively growing in late spring through the summer. Warm season grasses are generally benefited by a winter or spring burn. However, both cool and warm season grasses are adapted to fire at any time of the year. Annual grasses and forbs are usually killed if burned after they germinate. For a detailed discussion of fire effects on plants see OSU Fact Sheet F-2877, Fire Effects in Oklahoma.

The most important point to remember is that native plant communities developed with periodic fire over thousands of years. Native prairies, shrublands, and forests are resilient to fire and other disturbances in all seasons and conditions.

Other Suggested References

E-927, Using Prescribed Fire in Oklahoma

F-2876, Eastern Redcedar Control and Management – BMP's to Restore Oklahoma's Ecosystems

F-2877, Fire Effects in Oklahoma

Fire Danger Model at http://agweather.mesonet.org/rangeland/

Smoke Dispersion Model at http://agweather.mesonet.org/weather/

The Oklahoma Cooperative Extension Service
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Extension carries out programs in the broad categories of agriculture, natural resources and environment; family and consumer sciences; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

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- It is administered by the land-grant university as designated by the state legislature through an Extension director.
- Extension programs are nonpolitical, objective, and research-based information.
- It provides practical, problem-oriented education for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
- It utilizes research from university, government, and other sources to help people make their own decisions.
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