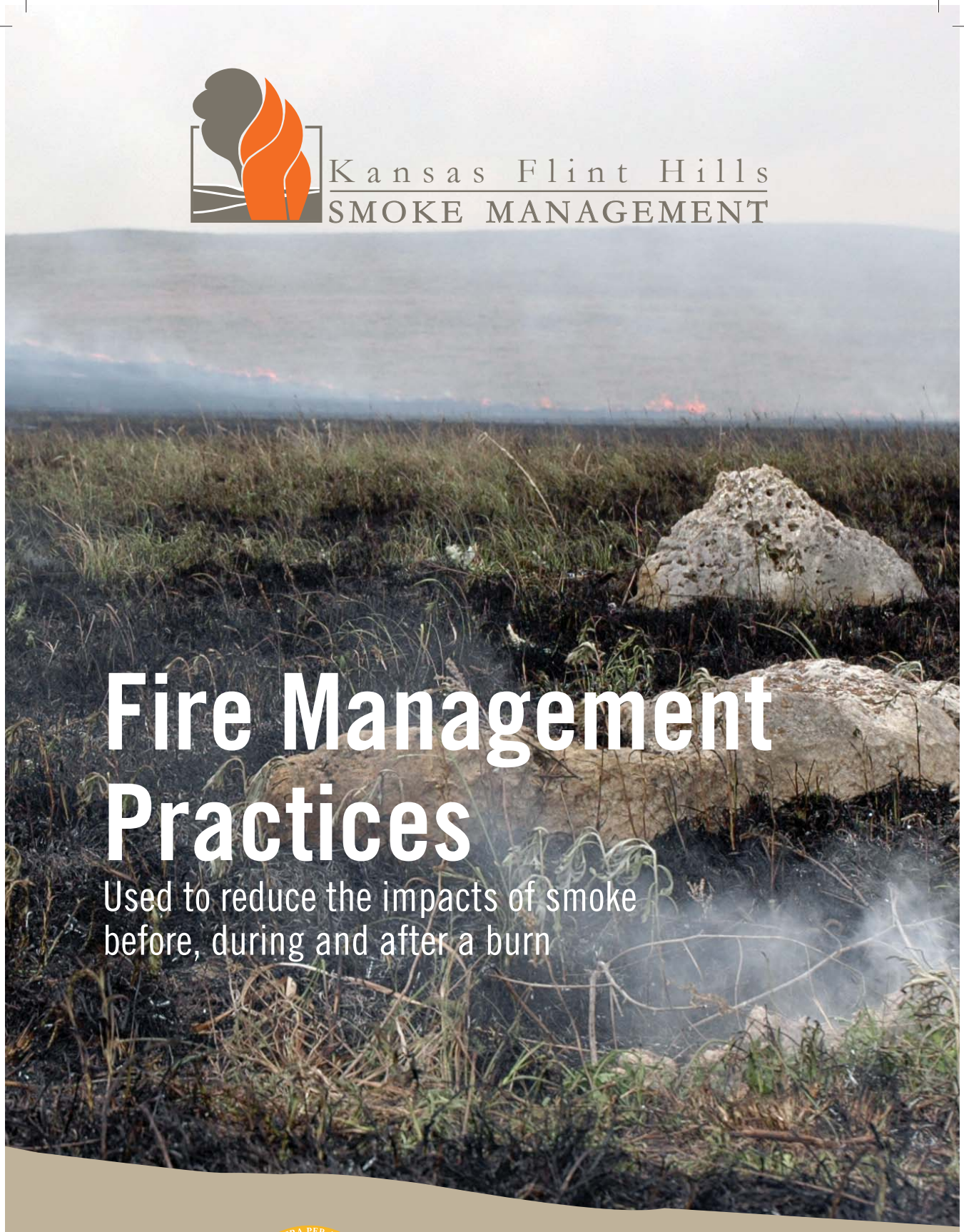
Kansas Flint Hills
SMOKE MANAGEMENT



Fire Management Practices

Used to reduce the impacts of smoke before, during and after a burn

Kansas
Department of Health and Environment

K-STATE
Research and Extension

Revised 2017

Prescribed fires and air quality

The Flint Hills require prescribed fire as a land management tool to prevent the encroachment of woody species and to stimulate warm season grasses for cattle. These cattle are the basis of the Flint Hills economy, and fires have long been used as an economical means to improve and maintain the natural and agricultural resources within Kansas. What is good for one area of Kansas has proven detrimental to other parts of the state as pollutants in the smoke have a negative impact on air quality. In recent years pollutants related to fires, particularly in the Flint Hills, have contributed to air quality problems in Kansas City, Wichita, and downwind states. One reason is that weather conditions often compress the time window in which a large number of acres are burned. The Kansas Department of Health and Environment (KDHE) has an established air monitoring network that records elevated concentrations of pollutants from the smoke emitted during these heavy burn episodes.

Pollutants in smoke

The Environmental Protection Agency (EPA) has established federal air quality standards for certain pollutants. These are health-based standards set to protect human health. KDHE provides data from the monitoring network on pollutant levels to EPA each year. One pollutant from agricultural fires is particulate matter. These particulates travel into the deepest part of the lungs causing serious breathing problems and contribute to premature death in individuals with heart or lung diseases. Nitrogen oxides and volatile organic compounds are also pollutants emitted. These pollutants contribute to the formation of ozone which aggravates asthma symptoms and even impairs the breathing of healthy individuals. Ozone is also the key pollutant of concern in Kansas City and Wichita, due to past and present exceedances associated with burning. Each time a monitor in the KDHE network records a pollutant level in excess of the federal air quality standard, that area is at increased risk for violating the standard. Violations lead to an area being given a negative air quality status designation from the EPA.

This "nonattainment" designation triggers a host of regulations that add to the costs of doing business for all Kansans.

April burn restrictions regulation

Kansas Administrative Regulation (K.A.R.) 28-19-645a, Open Burning Restrictions for Certain Counties during the month of April, supports the State of Kansas Flint Hills Smoke Management Plan (SMP). The regulation restricts certain burn activities that could contribute to the smoke from unrestricted prescribed range burning activities. This was enacted to decrease the risk of exceeding air quality standards outside of the traditional ozone season (summer months) in the Kansas City and Wichita MSAs. The regulation applies to the following counties: Butler, Chase, Chautauqua, Cowley, Elk, Geary, Greenwood, Johnson, Lyon, Marion, Morris, Pottawatomie, Riley, Sedgwick, Wabaunsee and Wyandotte and has been in effect since 2010. Beginning in 2017, the EPA has expanded the ozone season to include the months of March through October. Ozone, at ground-level, is formed from VOCs and oxides of nitrogen present in smoke from prescribed fires. However, the reaction that forms ozone requires warmer weather and longer daylight hours. These are conditions not typically seen in Kansas during the month of March, therefore the regulation remains in effect in April.

Burning that will continue to be allowed in these counties during April includes prescribed burning related to the management of prairie or grasslands (range or pasture management) and conservation reserve program (CRP) burning activities. Restricted activities include burning materials such as land clearing debris, crop residues, construction debris, fire fighter training burns, and yard waste. Existing exemptions in K.A.R. 28-19-647(a)(1) and (a)(2) have been retained in the regulation as K.A.R. 28-19-645a(b)(2) and allow for the following: (1) open burning on a residential premise containing five or less dwelling units and incidental to the normal habitation of the dwelling units; and (2) open burning for cooking or ceremonial purposes on public or private lands regularly used for recreational purposes. Other exemptions may be considered on a case-by-case basis for certain activities. The burning of storm debris would be a good example of a possible qualifying exemption. Burn activities not explicitly exempted in the new regulation will be subject to review and approval by KDHE. Any proposed burn activity must be proven to be necessary, to be in the public interest, and not to be prohibited by any local government or local fire authority. April burn activities involving nonagricultural land clearing debris and construction debris in Johnson, Wyandotte, and Sedgwick counties will be subject to review and approval by the respective local authorities.

Fire Management Practices (FMP) for air quality benefit

The State of Kansas Flint Hills Smoke Management Plan describes actions to help minimize the air quality impacts associated with prescribed fires while allowing the practice to occur in the state. The plan includes this Fire Management Practices (FMP) document as a resource for conducting burns that minimize smoke. These practices were developed in cooperation with KDHE and K-State Research and Extension. Additional resources are available at the Fire and Smoke Planning Resource website at **www.ksfire.org**. The website contains information on weather conditions and tools to assist land managers in predicting smoke plume variability.

Reducing downwind impacts of Flint Hills burning

FMP form the foundation of a good smoke plan along with information that will be made available via the Fire and Smoke Planning Resource website (www.ksfire.org). All of the FMP discussed below require a few pieces of information, most of which are found on the Fire and Smoke Planning Resource website. Local information such as soil moisture and fuel moisture are a function of individual field conditions and must be gathered in the field. A checklist of conditions is provided to help ensure FMP for air quality are being followed. The land manager should document and follow these FMP to ensure their individual burns are minimizing the potential for smoke impacts on downwind areas.

Should I burn this year?

The first question that a land manager should answer is "Do I need to burn to meet my objectives of land management?" The most obvious and effective method of smoke reduction is using a nonburning alternative or reducing the frequency of burns. For many land managers in the Flint Hills, a nonburning alternative is likely not available or cost effective due to the large acreages involved. Examples of nonburning alternatives for smaller pastures include spraying herbicides or physical removal of invasive woody species. Reducing the frequency of the burns may be a strategy that still allows for management objectives to be met. If burning is required, the land manager should plan a burn using FMP to minimize smoke and air quality impacts.

When should I burn?

Prescribed burning activities should be driven by a specific objective, related to the desired vegetative condition or management goal. A prescribed burn should be conducted when there is the greatest possibility of achieving management objectives. While prescribed burning activities and historic fires have and may occur throughout the year, land managers must choose, understand, and plan in advance the desired outcomes and schedule prescribed burn activities accordingly.

Different times of the year provide different vegetative responses to prescribed burning. When vegetative species are identified such as eastern red cedar or Osage orange (hedge), the land manager should time the prescribed fire to provide the greatest opportunity to impact target species. This may be as early as mid–February through late spring for the eastern red cedar, whereas Osage orange is affected after leaf emergence in late spring through the middle of the summer growing season. Land managers wishing to control cool-season grasses should burn after these plants are actively growing, generally in April.

Both game and nongame avian species should be considered when timing prescribed fires. Earlier prescribed burn activities in March benefit many forbs and legumes, which provide food and habitat for wildlife and the insects that wildlife eat. Nesting success for ground-nesting birds can be improved by burning before April 15 and after July 15. Leaving unburned, lightly grazed areas provides good nesting cover.

Land managers targeting animal performance as a primary objective typically schedule prescribed burn activities around favored vegetative species that produce the highest volume and quality forage during their growing season. For most warm season tall grass species in the Flint Hills of Kansas, this application target is during the month of April, with very late March or early April the target in the south, and late April to very early May being the target in the north. This is due to the longer growing season from south to north throughout the Flint Hills. This gives producers the opportunity to initiate prescribed burn activities earlier in the southern portion than in the north, due to targeted desirable warm season species breaking dormancy at an earlier date.

With all prescribed burn activities, land managers should understand planned management prior to and following the application of prescribed burning. Management before and following prescribed burn activities by grazing animals has the potential to impact the degree of success from prescribed fire activities both positively and negatively.

Fire Management Practices (FMP) for air quality benefit

There are several burn practices that can help reduce impacts on air quality. Most techniques involve minimizing smoke production by burning in conditions that allow for adequate smoke dispersal. In this section we outline these methods and describe how to achieve good results with specific types of burning. A land manager should consider all the conditions below before starting a burn. If conditions related to current or forecasted air quality are not favorable, the manager should consider rescheduling the burn.

KDHE and K-State Research and Extension identified the following FMP environment conditions that should be used by the land manager as a guide before burning. Land managers should be aware that meteorological conditions affecting burning can change considerably during a day. They should take this into consideration when making a decision on whether to burn or the number of acres to burn that day.

Air quality

Land managers should consider the overall air quality on the day of burning. This information can be obtained from EPA's Airnow website (**www.airnow.gov**). If conditions are ideal for burning, there may be many fires going at once, which can significantly degrade air quality. Figure 1 is a NASA visible satellite image showing heavy smoke plumes originating from fires in the Flint Hills. If there is a lot of smoke in the air, or if poor air quality is being forecast for a major metropolitan area that may be impacted by the burn, the land manager should consider rescheduling the burn to a day when less burning is occurring.

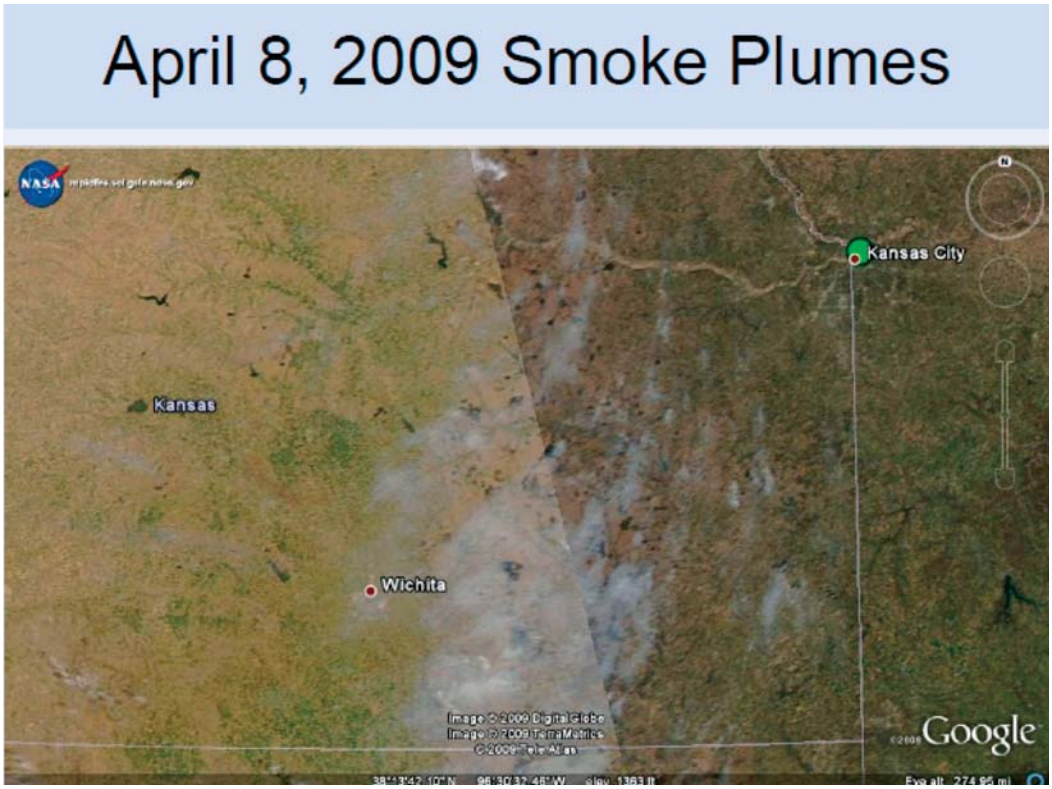


Figure 1. NASA visible satellite image showing heavy smoke plumes across eastern Kansas.

Transport wind

Land managers need to be aware of the impacts that transport and surface winds have on air quality. Transport wind generally refers to the rate at which emissions (smoke) will be transported from one area to another. Transport winds are one of the most important factors in ensuring good dispersion and minimal impacts on sensitive areas. Transport winds are a measure of the average rate of the horizontal transport of air within the mixing layer. It is also described as the wind speed at the final height of plume rise. Wind direction is a key consideration as sensitive areas downwind should be considered before initiating the burn. The Fire and Smoke Planning Resource website or your local National Weather Service office provides the current and forecast wind speed and direction for your burn location. The contact information for Kansas National Weather Service offices can be found at the end of this pamphlet. Smoke models on the ksfire.org website (*Figure 2*) provide a visual forecast of where the smoke plume will travel and its extent under the forecasted wind conditions. Smoke models were developed to predict downwind transport of pollutants but do not include the mechanisms to predict ozone formation. Models do provide

the land manager with predictions on the movement of ozone precursors. Smoke and the associated precursor pollutants for ozone can travel long distances, thus a land manager should consider impacts of sensitive areas both near and far. It is advised that burning should occur when winds are an appropriate direction and transport wind speeds are between 8-20 mph throughout the mixing height.

Surface winds, those at ground level, that are too light (less than 5 mph) will not move the smoke away from the ignition source causing an extreme smoke buildup with elevated ozone precursor and PM concentrations. Winds that are too strong (greater than 20 mph) will cause dangerous burning conditions.

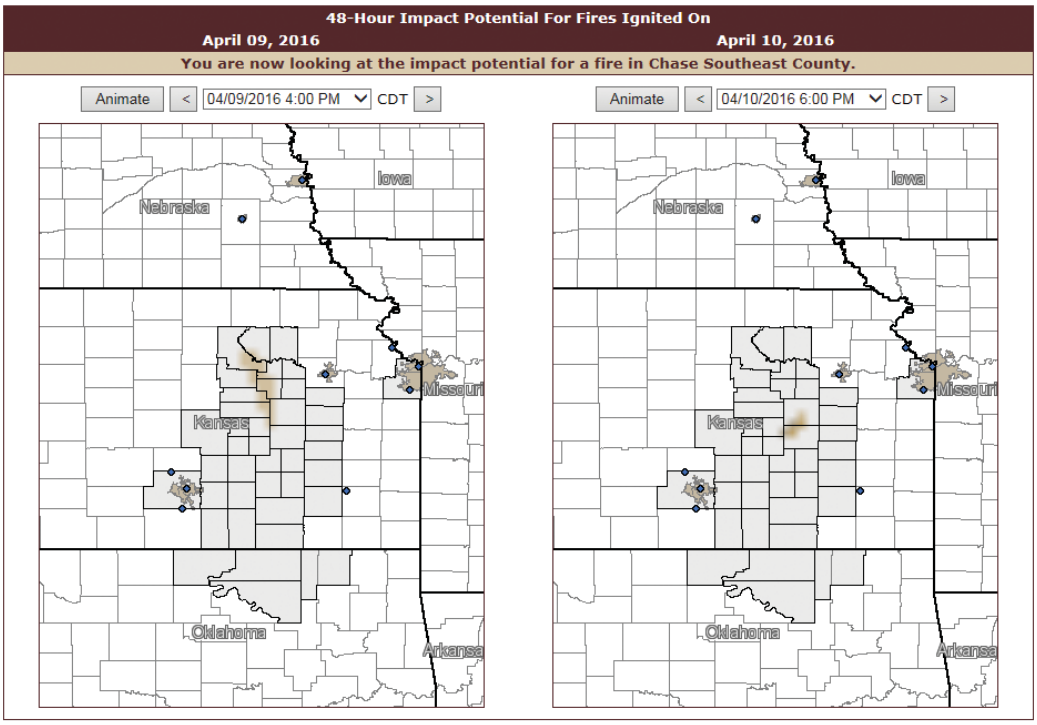


Figure 2. The Smoke Management Plan Modeling Tool is available on the website www.ksfire.org and can be used to see the forecasted plume direction.

Mixing height/dispersion

Mixing height is a term used to describe the potential for vertical mixing. It defines the height above the surface through which relatively vigorous mixing will take place in the vertical due to convection. The land manager can obtain the forecasted mixing height for the day by accessing their closest National Weather Service website. Once on the website the land manager should click on the forecast map where the burn will occur, then scroll down and click on the hourly forecast document. Dispersion

is the removal by whatever means of pollutants from the atmosphere over a given area; or the distribution of a given quantity of pollutant throughout a volume of atmosphere. Atmospheric conditions that limit the buildup of smoke are important for air quality. Dispersion occurs more readily under unstable atmospheric conditions. For best smoke dispersion, the land manager should ensure mixing heights are adequate to allow the smoke to rise away from the ground to disperse. Ideal mixing heights for burning generally occur after the sun has adequately heated the ground, hence the ideal burning hours being between two hours after sunrise to sunset. As the sun sets, the mixing height decreases, which traps smoke in a thinner layer of the atmosphere, increasing smoke concentrations (*Figures 3-4*). It is advised that burning should occur when mixing heights are 1,800 feet or higher.

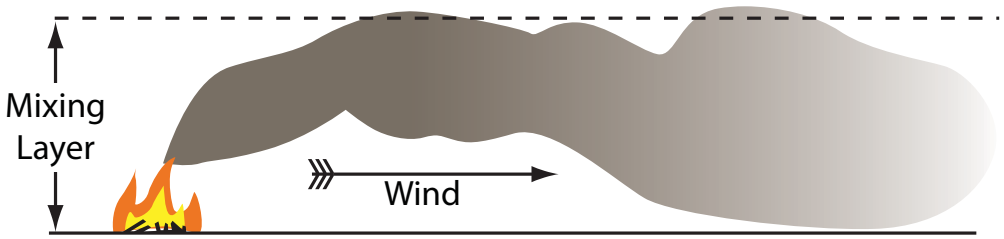


Figure 3. Indicators or poor ventilation - Winds are light and/or variable. Sounds carry a long way and it may be an overcast or foggy day. Stirred dust tends to hang around and linger. Smoke from fires tends to linger near the source or form a shallow trail that extends downwind.

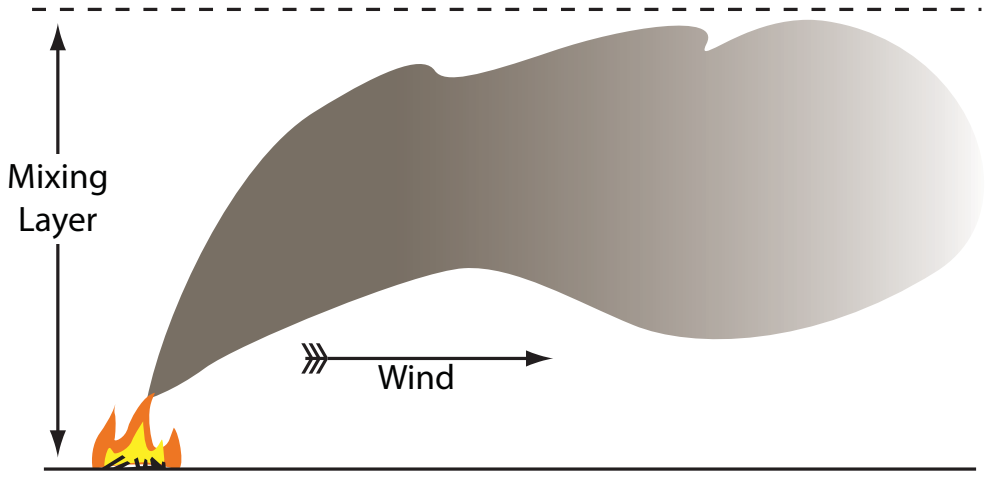


Figure 4. Indicators of good ventilation - Winds are 5 to 15 mph without significant gusts and wind direction is consistent. Clouds are high above the ground, indicating the mixing layer is deeper. Smoke rises quickly and/or disperses rapidly.

Time of day can impact smoke dispersion

Timing of a burn can significantly impact the dispersion of smoke. Burning should occur when the atmospheric and fuel conditions allow for minimal smoke impacts. The timing of a burn is important to ensuring good atmospheric conditions. For example, transport winds and mixing heights tend to decrease as the sun goes down, which can adversely impact dispersion. Burning too early in the morning, before the sun drives moisture from the fuel, may lead to poor burn characteristics, such as smoldering. It is advised that burning should generally occur two hours after sunrise to ensure that good atmospheric conditions exist.

Relative humidity/fuel moisture/air temperature

Humidity, fuel moisture, and air temperature can affect the fuel combustion. High relative humidity or high fuel moisture content affects the efficiency of the burn creating more smoke and smoldering conditions. Ideal relative humidity conditions for favorable burning occur in the range between 30-55 percent. Higher air temperatures can lead to better combustion; however, ozone formation increases at higher air temperatures. The land manager can obtain the relative humidity and air temperature for the day of a prescribed fire by accessing the Fire and Smoke Planning Resource website or the National Weather Service website for the location closest to the burn site.

Ignition and burn techniques

The type of prescribed fire (i.e. back fire or head fire) and the fuel load have an impact on the amount of smoke and other constituents produced. Fire initiation generally has a specific purpose: safety factors, fire transportation for complete burns, specific species control, and so on. Each type of prescribed fire can produce different volumes and qualities of smoke.

Reducing fuel loads through management practices, such as livestock grazing, can produce fewer smoke emissions. More frequent burning to reduce woody vegetation build-up also may reduce fuel loads. However, burning fewer acres to reduce overall smoke production may not necessarily produce less smoke if those acres have greater fuel loads.

Reducing burn time decreases the amount of smoke produced. Extinguishing smoldering areas produces less smoke and reduces overall

emissions. Smoldering is often associated with woody vegetation and denser canopy areas. Frequent burning results in less overall woody vegetation and therefore more rapid burn completion.

Efficient fuel combustion results in less smoke production. Smoke production is increased by the presence of green vegetation, which contains more moisture. Dryer fuels burn more efficiently. Grasses and forbs burn more cleanly than shrubs and woody species. Adequate wind speeds aid in complete combustion and prevent areas from excessive smoldering. Therefore, ideal conditions are dry matter with little to no woody vegetation and adequate winds to complete combustion.

There are trade-offs involved when selecting a smoke management FMP best suited to a particular situation. Backfires burn more efficiently than headfires, but headfires take less time to burn.

Other considerations

Cloud cover can also impact mixing heights. Cloudy skies prohibit the sun from hitting the ground, which prevents the heating needed to produce good mixing heights. Ideal conditions for a good mixing height often occur with cloud cover between 30-50 percent.

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Fire Management Practice (FMP) checklist

Preburn

Identify the area to be burned, the burn objectives, site characteristics, and desired atmospheric conditions.

- Area Identification – location, size and proposed dates of burns
- Objectives of the prescribed fires – forage improvement (yield, quality), weed/brush control (target weeds – recommended timing), wildlife habitat enhancement and CRP contract requirements
- Site characteristics – fuel condition (moisture, loading, type), soil moisture, and hazards
- Desired atmospheric conditions – wind direction, wind speed, relative humidity, air temperature, and cloud cover

Day of burn

Identify the conditions on the day of the burn. Check the Fire and Smoke Planning Resource website (**www.ksfire.org**). It is also recommended that a test fire be used to ensure the conditions are favorable for burning.

Time Fire Started _____

Wind Speed _____ (5-15 mph)

Wind Direction _____

Relative Humidity _____ (30-55 percent)

Air Temperature _____ (50-80° F)

Cloud Cover _____ (30-50 percent)

Trans. Wind Speed _____ (>8 mph)

Mixing Height _____ (min. 1800 ft or 548 m)

Soil Moisture _____ (saturated, moist or dry)

Fuel Moisture _____(moist or dry)

Existing Air Quality _____ (www.airnow.gov)

Forecasted Air Quality _____ (www.airnow.gov)

Checked Model Run? ☐ yes ☐ no

Predicted Model Color for Burn Area: ☐ red ☐ yellow ☐ green

Test Fire Behavior _____

_____

_____

_____

_____

_____

_____

Post burn

Hotspots Extinguished _____

Date/Time Fire Extinguished _____

Mop-up Completed _____

Final Perimeter Checked _____

Equipment Collected _____

Local Officials Notified Fire is Out _____

Total Acres Burned _____

Objectives accomplished? (weed control, forage improvement, wildlife habitat enhancement, or other)

Other issues (fire behavior, intensity, and control, weather issues, fuel conditions, equipment problems, staff report out, complaints, etc.)

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