Air Quality Concerns of Prescribed Range Burning in Kansas

Author, *Zifei Liu, Ph.D., Biological and Agricultural Engineering, Kansas State University*

Introduction

Prescribed range/pasture burning is a long-standing practice in Kansas used to enhance the nutritional value of native grasses and control invading weeds, trees, and brush. However, smoke plumes originating from these fires, particularly from burning in the Flint Hills region of eastern Kansas, have contributed to air quality concerns in the Kansas City and Wichita areas, and have affected several states downwind of Kansas.

Particulate matter and ozone precursors (nitrogen oxides and volatile organic compounds) are the smoke constituents of concern. The Kansas Ambient Air Monitoring Network has recorded elevated concentrations of both particulate matter and ozone in the air during periods of intensive range burning. Particulate matter causes haze and visibility concerns, while the fine particulates in smoke can contribute to health problems for anyone with respiratory illnesses. Ozone may aggravate asthma symptoms and impair the breathing of healthy individuals. Ozone is the key pollutant of concern in the Kansas City and Wichita communities, due to monitored exceedances of air quality standards.

Air quality regulation trends

The National Ambient Air Quality Standards (NAAQS) are evolving as new standards are developed for ozone and fine particulates. In 2006, the fine particulate 24-hour $PM_{2.5}$ (Particulate matter less than 2.5 μm in equivalent aerodynamic diameter) standard was reduced from 65 to 35 μg/m^3. In 2012, the primary annual standard of $PM_{2.5}$ was reduced from 15 to 12 μg/m^3. In 2008, the 8-hour ozone standard was reduced from 0.080 to 0.075 ppm, and a potential further reduction of the primary ozone standard to a range between 0.060 to 0.070 ppm is under discussion.

The continued lowering of ozone and fine particulate standards, together with the Regional Haze Regulations, will require changes in air quality management. In non-attainment areas where air quality violates the NAAQS, control measures must be implemented, which add significant regulatory and economic burdens. Air quality regulators are under pressure to quantify all sources contributing to poor air quality at a time of ever-tightening standards.

Prescribed burning is an important part of range management.

Prescribed range burning plans must be negotiated with the understanding that these plans compete for limited and decreasing allowable impacts on air quality. The interagency linkages between land managers and the air quality regulatory community are growing. Managers of future prescribed range burning will need to use all available information to reduce the smoke hazard.

Flint Hills smoke management plan

Existing regulations on agricultural burning are primarily enforced by local fire and emergency management personnel. Their primary concern is safety. However, the integration of smoke management efforts into fire management decisions becomes increasingly more important. As a result of exceedances of the ozone standard, in 2010, the Kansas Department of Health and Environment (KDHE) worked with stakeholders to develop a smoke management plan that recommended practices to reduce the air quality impacts of prescribed range burning in the Flint Hills. The plan is evaluated each year using input from stakeholders, which include land managers, the U.S. Environmental Protection Agency, and environmental groups. The plan is largely voluntary. A data collection pilot program was developed and a smoke

planning checklist is available as a form on the Fire and Smoke Planning Resource website (www.ksfire.org). Land managers are encouraged to document the number of acres burned, fuel load, and weather conditions for the prescribed burning activities. The goal is to develop a reporting system that would make this information more accurate, while protecting the privacy of landowners. After each burn season, air monitoring data from the existing KDHE network, weather conditions, and remote sensing data from satellites are examined by KDHE and shared with stakeholders.

Smoke management best practices

Recommended smoke management practices are summarized in Figure 1. These practices included recommendations from *Basic Smoke Management Practices* published by the Natural Resources Conservation Service (NRCS, 2011), as well as from the Kansas Flint Hills Smoke Management Plan (2010). Land managers can implement these practices to address air quality concerns associated with prescribed range burning. Before burning, land managers have several tasks to complete, including identifying the burn objective and developing a comprehensive burn plan. Appropriate authorities, neighbors, and others potentially affected by smoke should be notified. While burning, it is important to monitor and retain information about the weather, burn, and smoke. If air quality problems occur, documentation helps analyze and address air regulatory issues. After the burn, an evaluation of the success and impact of the burn is recommended.

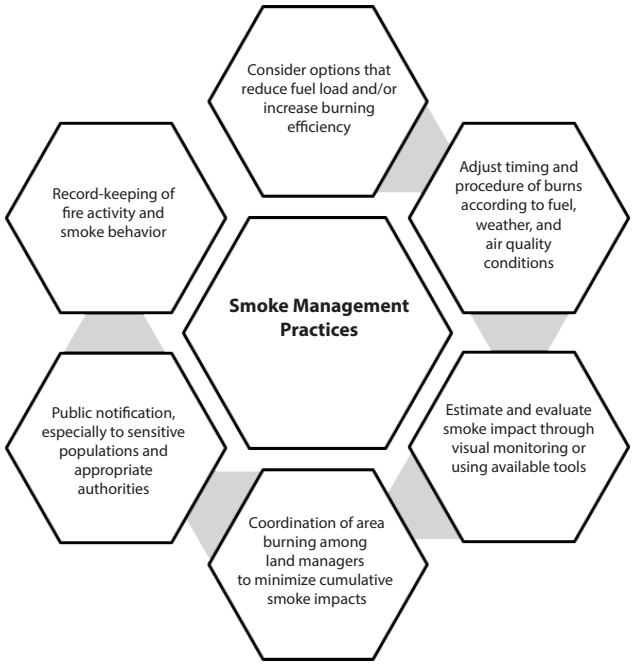

Figure 1. Smoke management practices to address air quality concerns. *(Adapted from NRCS Basic Smoke Management Practices, 2011, and Kansas Flint Hills Smoke Management Plan, 2010)*

Frequency of burns

One method of smoke reduction is to use a non-burning alternative, such as mowing or chemical control of invasive woody species. Another method would be to reduce the frequency of burns. Although scientific consensus supports the economic and ecological need for prescribed fires in native grasslands, there is debate regarding optimal burn frequency. While annual burns are preferred for optimal stocker cattle gains, other management goals (such as woody plant control) may be achievable with less frequent burns.

The frequency of burns usually varies from yearly to every third year, depending on the type of livestock operation (e.g., cow-calf, season-long yearlings, and short-season stockers), burning constraints, and weather/grass growth conditions. Frequent burning increases the number of acres burned each year, but it may also result in more rapid and complete burn due to less build-up of woody vegetation. Patch-burn grazing (PBG) has been suggested as a way to promote biological diversity in the Flint Hills and has the potential to reduce smoke emissions. Typically, one-third of a PBG range is burned each year on a rotational basis.

Timing of burning activities

The timing of prescribed burning activities is usually driven by specific management goals related to the desired vegetative conditions or animal weight gains. Timing of a burn also can significantly affect the production and dispersion of smoke. With air quality concerns, land managers should time their burns to ensure favorable fuel conditions and weather conditions to reduce smoke impact.

Burning at different times of the year results in different vegetative responses, although rangelands are resilient to fires at any time of year. Factors to consider when timing a burn are summarized in Figure 2. To maximize warm season tall grass production, prescribed burn activities in the Flint Hills are generally conducted during April. Weather conditions and safety issues further limit the number of suitable days for burning. Good air quality can be compromised when too many burns occur and a large amount of smoke is released into the air during a short time period. To partially address this problem, the Kansas Flint Hills Smoke Management Plan includes some restrictions on nonessential burning in April.

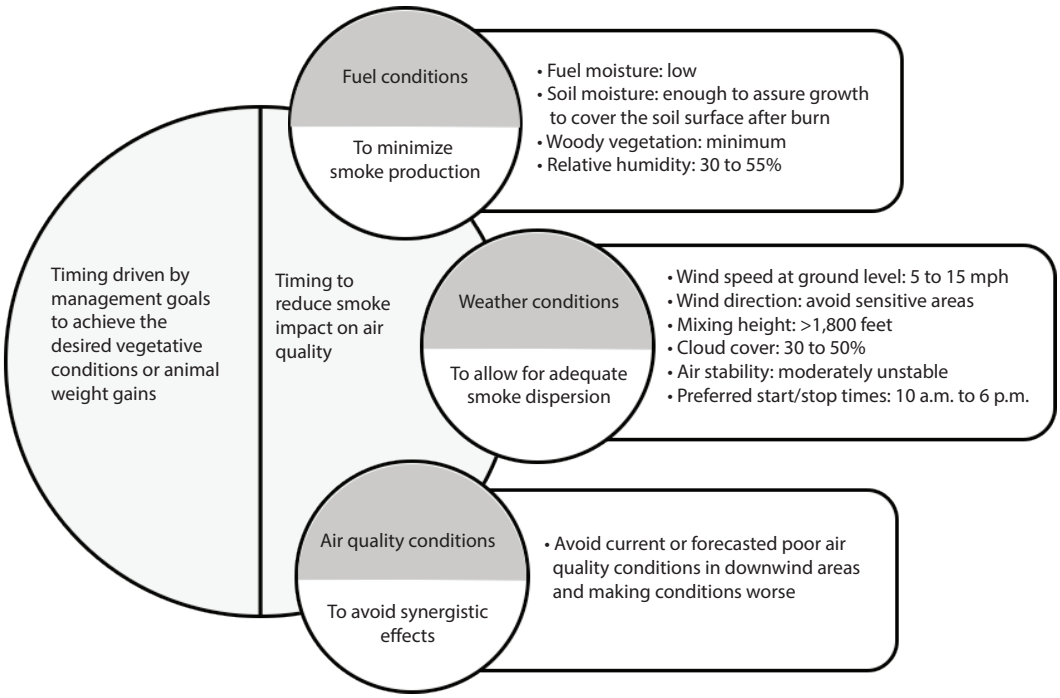

Figure 2. Considerations in timing of prescribed burning activities. *(Adapted from the Kansas Flint Hills Smoke Management Plan, 2010)*

Fuel conditions

Efficient fuel combustion results in less smoke production. High moisture levels in the fuel (grass/trees/brush) reduce combustion efficiency and produce more smoke. This water vapor from fire can condense onto fine particulate matter and increase haze formation. Grasses and forbs burn more efficiently than shrubs and woody species. Woody vegetation and denser canopy areas are often associated with smoldering conditions, which produce more smoke. Reducing fuel loads through management practices such as livestock grazing can reduce overall smoke emissions. Conditions contributing to efficient fuel combustion include minimal woody vegetation, low humidity of both air and fuels, ignition methods that create large, intense fires, and adequate winds to complete combustion.

Weather conditions

Wind and atmospheric stability influence the way smoke is dispersed. Desirable weather conditions allow for adequate smoke dispersion to reduce smoke impacts on air quality. Adequate wind speeds help disperse a plume, but strong winds also may cause a plume to bend over near the ground and inhibit vertical dispersion. Also, burning should occur when wind direction has minimal impacts on sensitive areas. Atmospheric stability refers to the atmosphere's ability for vertical motion, which is promoted by wind (causing turbulence) and heating effects (causing convection). In unstable conditions, the warmer, lighter air at ground level rises and mixes with the cooler air in the upper atmosphere, dispersing ground level pollution. In contrast, a very stable condition occurs when the air temperatures increase with height, which is referred to as a "temperature inversion," because the warmer air above cooler air acts like a lid, suppressing vertical mixing. For this reason, burning under a persistent temperature inversion is not recommended.

Mixing height defines the height above the ground through which relatively vigorous mixing will take place. Ideal mixing heights for burning generally occur during the day after the sun has adequately heated the ground. Mixing heights tend to decrease as the sun goes down. Clouds can reduce mixing heights because they prevent the sun from heating the ground, which is needed to promote convection. On the other hand, clouds are advantageous because they limit ozone formation through a reduction in photochemical reactions. Ideal burning conditions occur with cloud cover between 30 and 50 percent. Land managers can obtain information on weather conditions by accessing the National Weather Service Fire Weather Forecast website (www.srh.noaa.gov/ridge2/fire/).

Air quality conditions

When poor air quality conditions are observed or are forecasted in areas that may be affected by smoke, a burn should be rescheduled, if possible, to avoid making the conditions worse. Poor air quality is usually associated

with weather conditions that do not favor dispersion of air pollutants. However, on a day with suitable weather conditions for burning, too many burns may occur at the same time. Preferably, burning can be planned cooperatively so as not to overwhelm the ability of the atmosphere to disperse the smoke. Land managers can obtain air quality information from EPA's AIRNOW website: (www.airnow.gov/).

Estimation and modeling tools for smoke management

You may find the online smoke screening tool at ksfire.org useful when planning a burn. This tool can predict where and how smoke will travel and the potential for smoke from a particular location to affect concerned communities. The results help land managers determine whether burning should occur and to what extent it should occur to avoid air quality problems. More sophisticated modeling tools are being developed for better smoke management related to prescribed fires. Emission modeling tools take into account the fire activity information to calculate fuel consumption and to characterize smoke emissions. Smoke dispersion modeling tools take into account the weather conditions, along with the smoke emission data to evaluate impacts of smoke and the resulting concentrations of air pollutants to avoid exceedances of air quality standards. At a time of ever-tightening air quality standards, the need for further refinements of these tools continues to increase.

Smoke science and research

Ever-tightening air quality standards reinforce the need for increased knowledge and action on smoke issues and air quality. Currently, emission calculations for prescribed range burning are not accurate and reliable, due to a lack of information on areas burned, fuel load and combustion rates, and insufficient knowledge of emission factors. A high-quality smoke emissions inventory is critical in order to reduce uncertainty as to how fire should be managed. Also, in response to potentially more stringent ozone and fine particulate standards, air quality management is demanding higher levels of competency in smoke modeling as well as objective evidence that smoke models can provide accurate and reliable results. In circumstances where fire, climate change, and growing populations are interconnecting, it is clear that scientists and range managers need to improve understanding of the impact of smoke on human health and the health of the surrounding ecosystems, as well as the public perception of smoke. In 2010, the Joint Fire Science program conducted a wildland fire needs assessment and published a smoke science plan, which identified the following four linked and complementary research themes: smoke emissions inventory, smoke model validation, smoke and populations, and climate change and smoke.

Resources and references

Basic Smoke Management Practices. NRCS, 2011. Available at ftp://ftp-fc.sc.egov.usda.gov/AIR/smoke/BasicSmokeManagementPractices.pdf

EPA's AIRNOW website: www.airnow.gov

Joint Fire Science program Smoke Science Plan. 2010. Available at http://www.firescience.gov/documents/smoke/2010_JFSP_Smoke_Science_Plan_Final_Version_without_Appendix_B_1.0.pdf

Kansas Flint Hills Fire and Smoke Planning Resource website: www.ksfire.org

National Weather Service Fire Weather Forecast website: www.srh.noaa.gov/ridge2/fire/

National Smoke Management website: www.nifc.gov/smoke

The National Oceanic Atmospheric Administration (NOAA) Hazard Mapping System (HMS): www.osdpd.noaa.gov/ml/land/hms.html

State of Kansas Flint Hills Smoke Management Plan, KDHE, 2010. Available at www.ksfire.org/doc4661.ashx

Publications are reviewed or revised annually by appropriate faculty to reflect current research and practice.
Date shown is that of publication or last revision.

Publications from Kansas State University are available at: *www.ksre.ksu.edu*

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF3121 February 2014