State of Kansas
Flint Hills Smoke Management Plan
December, 2010

Department of Health and Environment
Division of Environment
Bureau of Air

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Table of Contents

FOREWORD **4**

CHAPTER 1. INTRODUCTION **5**

1.1 BACKGROUND OF AIR QUALITY IMPACTS OF FLINT HILLS BURNING IN KANSAS 5
1.2 THE FLINT HILLS ECOSYSTEM 6

CHAPTER 2. REASONS FOR HAVING A SMOKE MANAGEMENT PLAN IN KANSAS **9**

2.1 HEALTH CONCERNS 9
2.2 NATIONAL AMBIENT AIR QUALITY STANDARDS 10
2.2.1 Particulate Matter *10*
2.2.2 Ozone *11*
2.3 EPA INTERIM POLICY AND GUIDANCE ON WILDLAND AND PRESCRIBED FIRES 12
2.4 NONATTAINMENT – CONSEQUENCES AND COSTS 13
2.5 MAINTAINING THE FLINT HILLS AND THE RELATED AGRICULTURAL ECONOMY 14
2.6 SUMMARY 18

CHAPTER 3. REDUCING DOWNWIND IMPACTS OF FLINT HILLS BURNING **18**

3.1 SHOULD I BURN THIS YEAR? 18
3.2 WHEN SHOULD I BURN? 19
3.3 FIRE MANAGEMENT PRACTICES (FMPS) FOR AIR QUALITY BENEFIT 19
3.3.1 Air Quality *20*
3.3.2 Transport Wind *21*
3.3.3 Mixing Height/Dispersion *21*
3.3.4 Timing *22*
3.3.5 Relative Humidity/Fuel Moisture/Air Temperature *22*
3.3.6 Ignition and Burn Techniques *22*
3.3.7 Other considerations *23*
3.4 SMOKE PLAN PILOT PROJECT 23
3.5 SUMMARY 23

CHAPTER 4. APRIL BURNING RESTRICTIONS **24**

CHAPTER 5. OUTREACH, EDUCATION AND PUBLIC NOTIFICATION **25**

5.1 OVERVIEW 25
5.2 OUTREACH METHODS 26
5.2.1 Predictive Model *26*
5.2.2 Formal Fire Instruction *26*
5.2.3 Internet *27*
5.2.4 Broadcasting *27*
5.2.5 Print *27*
5.2.6 Group Presentations *27*
5.3 AUDIENCES AND MESSAGE CONTENT 27
5.3.1 Land Manager *27*
5.3.2 Agency (including municipalities) *28*
5.3.3 Regulatory *28*
5.3.4 Businesses *28*
5.3.5 Public *28*
5.4 EDUCATION AND OUTREACH WORKGROUP 28

CHAPTER 6. SURVEILLANCE AND ENFORCEMENT **28**

CHAPTER 7. DATA COLLECTION, RESEARCH NEEDS AND LONG TERM STRATEGIES **29**

7.1 DATA COLLECTION 29
7.1.1 Data Collection Pilot Program *29*

DRAFT

7.2 RESEARCH NEEDS 29
7.2.1 Characterize emissions associated with Flint Hills burning 29
7.2.2 Using remotely sensed data for fuel biomass loading 30
7.2.3 Monitoring Studies 30
7.2.4 Timing and frequency of burns 30
7.2.5 Management techniques 30
7.2.6 Health Impacts 30
7.2.7 Burning Affects on Prairie Chicken Populations 31
7.3 LONG TERM STRATEGIES 31
7.3.1 Modeling 31

CHAPTER 8. SMP EVALUATION AND CONTINGENCY MEASURES 32

8.1 INTRODUCTION 32
8.2 TECHNICAL INFORMATION GATHERED DURING BURN SEASON 32
8.3 POST BURN SEASON REPORT 32
8.4 LAND MANAGER SURVEY 33
8.5 CONTINGENCY MEASURES 33

LITERATURE CITED 36

APPENDIX A - OZONE, PM_{10} AND $PM_{2.5}$ MONITORING LOCATIONS IN KANSAS 37

APPENDIX B – METEOROLOGICAL CONDITIONS FOR SMOKE DISPERSION 39

APPENDIX C – FIRE MANAGEMENT PRACTICE (FMP) CHECKLIST 40

APPENDIX D - CURRENT REGULATIONS ON BURNING 42

OPEN BURNING RESTRICTIONS 42
28-19-645. Open burning prohibited. 42
28-19-646. Responsibility for open burning. 42
28-19-647. Exceptions to prohibition on open burning. 42
28-19-648. Agricultural open burning. 44

APPENDIX E - EDUCATION AND OUTREACH ACTIVITIES 45

APPENDIX F - GLOSSARY 48

APPENDIX G – KANSAS NATIONAL WEATHER SERVICE CONTACT INFORMATION 53

DRAFT

Foreword

The actual beginning of the process that has led to the development of this plan began in the fall of 2003, when KDHE staff presented information regarding the effects of the Flint Hills burning on ozone levels to agricultural interests at a conference at Kansas State University (KSU). KSU range management researchers, KSU Research and Extension, the Kansas Department of Agriculture, the Kansas Livestock Association, and other agricultural interests were all present at the meeting. With the help of the organizations present, KDHE planned to take an initial voluntary/educational approach to addressing the issue. KDHE continued to engage the agricultural community on this issue in the following years and after a second episode in April 2009, in which the smoke from the burning in the Flint Hills contributed to exceedances of the ozone standard in Kansas City and Wichita, KDHE and the agricultural community agreed that a more formal plan to address this issue needed to be developed. In early 2010, after several informal meetings and hearings by the Senate Natural Resources Committee on this issue, a formal Flint Hills Smoke Management Advisory Committee was formed to begin the task of developing a Smoke Management Plan (SMP) for the Flint Hills. This committee was co-chaired by Senator Carolyn McGinn, Representative Tom Moxley and the Director of the Division of the Environment at KDHE, John Mitchell, and included a wide range of stakeholders including the Kansas Department of Agriculture, Kansas Fire Marshal, Kansas Division of Emergency Management, Kansas Forest Service, Kansas State University, City of Wichita, Johnson County, Natural Resources Conservation Service, Kansas Livestock Association, Kansas Farm Bureau, Tallgrass Legacy Alliance / Greenwood County Extension, The Nature Conservancy, American Lung Association (Wichita), Kansas Prescribed Fire Council/KS Grazing Lands Coalition, Kansas State Firefighters Association, Kansas Emergency Managers Association, Audubon of Kansas and the Kansas Forage and Grasslands Council.

The first large meeting of the group occurred in April 2010 and at that time the advisory committee formed a smaller subcommittee that was tasked to write the Flint Hills SMP. This subcommittee met several times during the late spring and early summer and developed several draft concepts of items to be included in the SMP. These ideas and a draft outline of the SMP were then presented at a second meeting of the SMP Advisory Committee in August. Additional meetings and conference calls of the subcommittee addressed remaining issues and the full draft of the Flint Hills SMP was presented to the Advisory Committee at its third meeting in November. The last meeting of the Committee occurred in early December and included an invitation to the general public to comment on the final draft of the Flint Hills SMP. The plan that has been developed represents a positive first step towards reducing the impacts of Flint Hills burning on air quality and in downwind areas. The plan includes contingency measures to be evaluated for potential adoption in the event that further actions are needed.

The KDHE would like to thank all those individuals and organizations, especially those on the subcommittee, which worked many hours on the development of this Plan.

DRAFT

Chapter 1. Introduction

Prescribed fires have long been used in Kansas to improve and maintain the natural and agricultural resources within the state. In recent years emissions related to prescribed fires, particularly in the Flint Hills, have contributed to air quality problems within the state and in downwind states. This document describes a plan to help minimize the air quality impacts associated with prescribed fires while continuing to allow the practice to occur in the state.

1.1 Background of Air Quality Impacts of Flint Hills Burning in Kansas

The Flint Hills region of Kansas is the last, large expanse of unplowed tallgrass prairie in North America. A long tradition of fire management by private ranchers to improve rangeland productivity has prevented the intrusion of woody and other undesirable plants into the prairie. Burning of the tallgrass prairie in the Flint Hills generally occurs in early to late-April to stimulate warm season grasses, particularly big bluestem, and to control undesirable woody species; burning earlier in the spring does not control resprouting woody species. With the majority of prescribed fire activities occurring during this time period, a large amount of particulate matter and ozone precursors are released into the air during a relatively short time period

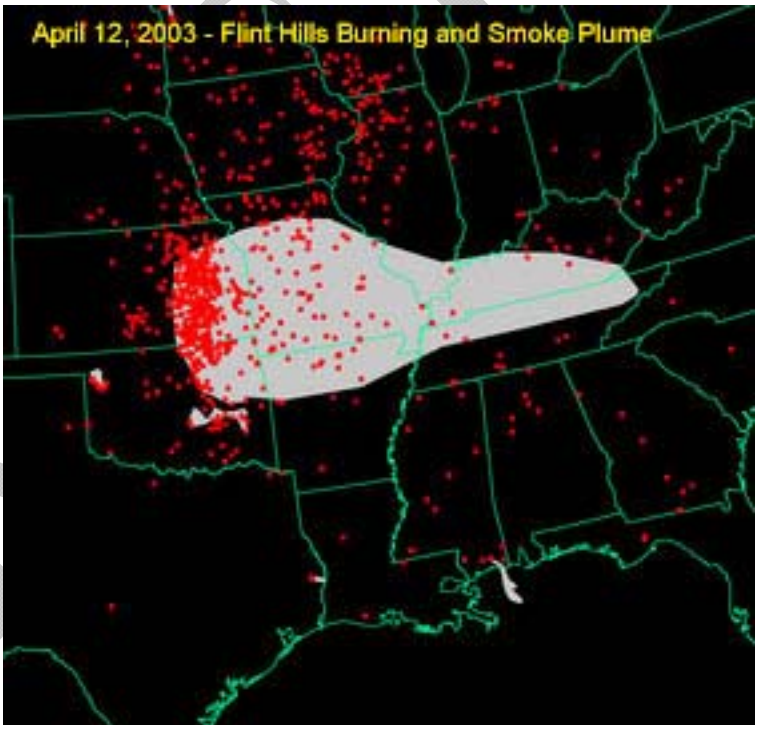

Figure 1. NOAA analyzed satellite image showing the smoke plume (gray area) originating from the Kansas Flint Hills region. (NOAA)

The burning in the Flint Hills and the potential impacts that burning has on public health first gained publicity in 2003. In 2003, air quality monitors that measure ozone in the Kansas City area recorded very high ozone readings on April 12 and 13. Three monitors in Kansas City, Missouri recorded readings that exceeded the federal 8-hour ozone standard. As can be seen in the satellite image in Figure 1, the smoke plume impacted several states east of Kansas. KDHE received numerous complaints from cities and states as far away as Tennessee about poor air quality and high ozone readings.

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More recently, Kansas Ambient Air Monitoring Network monitors have recorded elevated concentrations of both particulate matter and ozone as well as other pollutants downwind of the Flint Hills region. This has led to an increased interest in the air quality impacts of fires, not only in Kansas, but throughout the downwind states during the time frame in which the majority of prescribed fire activities occur.

1.2 The Flint Hills Ecosystem

Grasslands once covered much of middle North America, making up the continent's largest vegetative area. While significantly diminished following Euro-American settlement, North America's native prairies (short, mid and tall) still represent extensive areas of native plant and animal communities. The eastern third of this vast grassland region is represented by tallgrass prairie, a mosaic of distinct herbaceous-dominated communities. Tallgrass prairie is characterized by higher rainfall than mid and shortgrass prairies to the west, and is represented by a few dominant warm-season grasses and numerous herbaceous perennial forbs.

Climate, grazing and fire, each operating at multiple scales, frequencies and intensities, were the primary ecological processes that shaped the tallgrass prairie ecosystem. Seasonal precipitation and temperature patterns influenced the growth of vegetation, which in turn affected the availability of fuels for burning and forage for grazing. Frequent fire, interacting with grazing and climate, perpetuated a diverse vegetation mosaic across the prairie landscape. Bison and elk, the principal historic herbivores, grazed preferentially on vegetation in burned areas because of greater productivity and nutritive quality of forage following fire. Their transitory grazing patterns allowed the vegetation to recover from intermittent and sometimes intensive grazing events. These grazing patterns further impacted the availability of fuel for fire and, in turn, helped maintain the vegetation mosaic. People living on the landscape influenced these patterns and played a large role in shaping the historic landscape prior to Euro-American settlement.

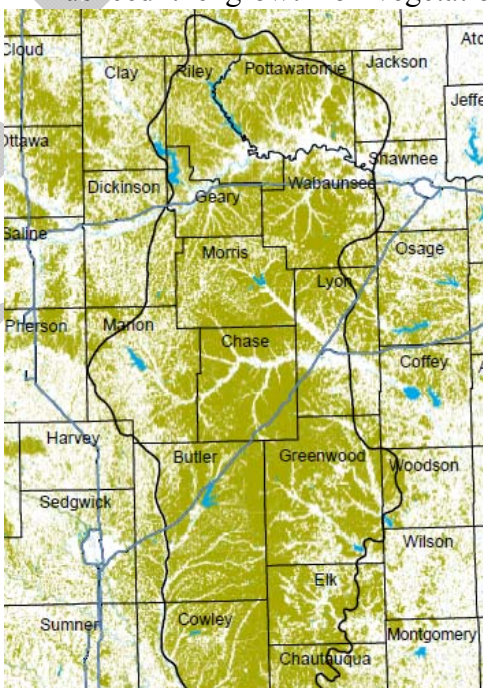

Figure 2. Kansas Flint Hills Ecosystem outlined in black. 2004 Statewide USDA National Agriculture Imagery Program (NAIP)
Grassland/Herbaceous and Water Classes

Deep-rooted prairie plants created some of the most fertile soils in the world, making the tallgrass region prime for agricultural development. Much of the historic tallgrass prairie was converted to cropland in a single decade, as railroads and Land Acts provided economic incentives. Tallgrass prairie once stretched across 170 million acres, from Canada to Texas and Kansas to Kentucky. Today, only about 4 percent remains. Few places in the world have experienced the extent of anthropogenic alteration documented

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in the tallgrass, making this once expansive, complex ecosystem one of the most altered in North America in terms of acres lost.

Still relatively unspoiled are the Flint Hills in eastern Kansas (Figure 2) and northeast Oklahoma[1], an extensive, landscape expression tallgrass prairie. Unlike the now-vanished tallgrass prairies that once blanketed much of the American heartland, this prairie landscape of gently-sloping limestone and chert hills remains today as the continent's last significant, unfragmented expanse of tallgrass prairie. Roughly two-thirds of all tallgrass prairie in North America is contained in the Flint Hills.

Figure 3. Male Greater Prairie Chickens, Lyon County

The Flint Hills provide a unique ecosystem representation of tallgrass prairie. Historically bison served as a keystone species in maintaining biodiversity, but today cattle serve as its surrogate. This large and intact area of tallgrass prairie is perhaps most important to grassland nesting birds, including the greater prairie-chicken (Figure 3), upland sandpiper, grasshopper sparrow, Henslow's sparrow and other species of conservation concern. The Flint Hills are also thought to provide an important north-south grassland corridor for migrating birds, such as the American golden plover, buff breasted sandpiper and Sprague's pipit. Because of their scale, the Flint Hills harbor one of the continent's largest populations of greater prairie-chickens.

Once believed relatively stable, populations of prairie-chickens in the Flint Hills have declined significantly since the 1980s. Part of the decline is linked to habitat fragmentation from tree encroachment and other habitat intrusions, but is also associated with a lack of residual vegetation for nesting. Fire and grazing are not in themselves detrimental to grassland bird reproduction, and in fact are essential ecological processes; but a decline in reproductive success may occur when the two are combined with high frequency. Henslow's sparrow (Figure 4), which requires areas of ungrazed or lightly grazed prairie with at least one year's accumulation of residual vegetation, has also experienced population declines. On the other hand, annually burned pastures provide nesting habitat for species that utilize or even prefer short stature vegetation, such as upland sandpiper (Figure 5), horned lark and grasshopper sparrow. Burned pastures also provide year-long foraging habitat for grassland birds, winter cover and the landscape context needed for area sensitive species like prairie chickens. Spring migrants like American

Figure 4. Henslow's Sparrow

[1] The Osage Hills (in Osage County, Oklahoma) represent a southern extension of the Greater Flint Hills landscape.

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golden plovers and buff-breasted sandpipers also seek out burned pastures as foraging areas in the spring.

Figure 5. Upland Sandpiper

The U.S. Fish & Wildlife Service and The Nature Conservancy have both identified the Flint Hills as a priority conservation action site. Likewise, the Kansas Natural Heritage Inventory rates the Flint Hills as the state's No. 1 landscape conservation priority and the World Wildlife Fund recognizes the landscape as "one of only six grasslands in the contiguous U.S. that is globally outstanding for biological distinctiveness". In 2001, The Nature Conservancy launched its Flint Hills Initiative, a community-based conservation initiative, to employ multiple strategies to help preserve the biological integrity of the region. The Nature Conservancy also has an impressive portfolio of conservation landholdings in the Flint Hills totaling more than 60,000 acres. These include Konza Prairie, which is operated as a field research station by the Division of Biology at Kansas State University, and the Tallgrass Prairie National Preserve, a unit of the National Park Service. The Nature Conservancy, Kansas Land Trust, Ranchland Trust of Kansas and USDA's Natural Resources Conservation Service (NRCS) also hold more than 60,000 acres of conservation easements in the Flint Hills. Since 2004, these entities have invested more than $12 million in land conservation in the Kansas Flint Hills.

Fire is well documented as a key ecological driver in grassland communities and is utilized by all of the above mentioned organizations as an ecological management tool (Figure 6). Fire is particularly important in grasslands that receive high precipitation to counter woody encroachment. Lightning-caused fires presumably drove the region's early beginnings as a fire/herbivore-driven plant community. Fire frequency is believed to have increased dramatically as humans gained more of a presence. In fact, Native American burning may have been the dominant ecological force for the past 10,000 years. This increased use of fire is believed to have resulted in an eastward expansion of the tallgrass region.

Figure 6. Burning in Wabaunsee County

Tallgrass prairie requires fire on a relatively frequent basis to prevent the encroachment of woody species and maintain the integrity of plant communities. Estimates of pre-1840 fire occurrence rates in tallgrass prairie vary from an annual regime (Edwin et al. 1996), 2 to 5 times per decade (Hulbert 1973) and every 5 to 10 years (Wright and Bailey 1982). Cutter and Guyette (1994) estimated a 2.8-

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year fire interval for a Missouri Savanna, while Bragg and Hulbert (1976) found evidence of a 3 to 5 year pre-settlement burn interval for Nebraska and Kansas tallgrass prairies. Given the historic extent of tallgrass prairie and assuming a 3-5 year historic fire-return interval, 30 to 60 million acres of tallgrass prairie would have burned on average each year.

Chapter 2. Reasons for Having a Smoke Management Plan in Kansas

There are three main reasons for adopting and implementing a smoke management plan in Kansas. The most obvious and important reason is to protect the health of Kansas citizens. The two other reasons are associated with the consequences of burning, both good and bad. Each of these three reasons is discussed in detail in the following sections. The existing Kansas regulations on agricultural burning were written originally to deal with safety, specifically vehicular and airport safety as it pertained to smoke from fires covering a roadway or runway. These regulations are found in Appendix D. Therefore this plan does not discuss those concerns directly but addresses the health and air quality impacts from agricultural burning in the Flint Hills.

2.1 Health Concerns

Pollutants resulting from industry, transportation, and open burning all affect the air quality in Kansas. The most common air pollutants in the rural areas of Kansas are particulate matter and ozone. Particulate matter is the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using a microscope. Microscopic particulates that have a diameter less than or equal to 10 µm or 2.5 µm are called PM_{10} and $PM_{2.5}$, respectively. By comparison, a human hair is about 70 µm in diameter. The small size and weight of these particulates allow them to remain airborne for weeks and to be transported long distances. Toxins and gases can also absorb into or coat these tiny particles, which pose a further health concern. Ozone develops when oxides of nitrogen react with hydrocarbons and other volatile organic compounds in the presence of sunlight. Ozone and the precursor pollutants that form ozone can also be transported long distances.

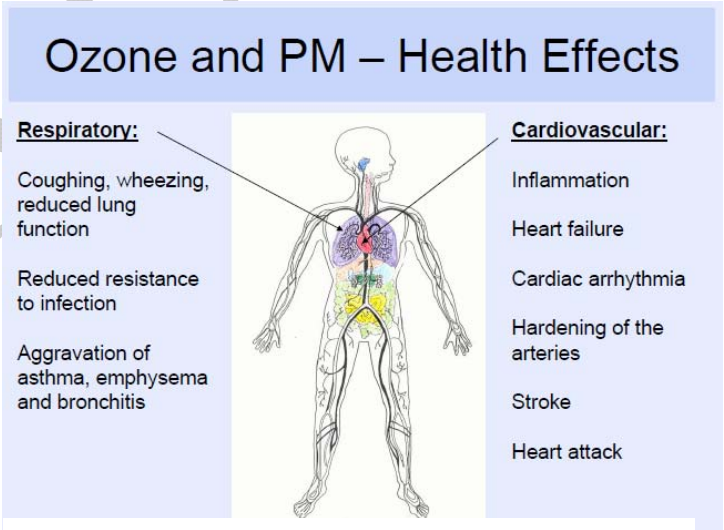

Figure 7. Health Effects of Ozone and Particulate Matter on human health.

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Smoke is a mixture of gaseous air pollutants and particulate matter. The particulate matter produced by burning vegetative matter consists of particles of soot (unburned carbon), ash (unburned minerals), condensed fumes (including toxic and potentially cancer-causing aerosols) and other products of incomplete combustion. When inhaled, PM_{10} and $PM_{2.5}$ particles and any toxins present can travel past the protective lining of the airway and into the deepest part of the lungs. Not all the particles can be expelled when you exhale, and particles retained in the lungs can cause serious harm (Figure 7).

The gaseous pollutants emitted during burning include carbon monoxide, hydrocarbons, and oxides of sulfur and nitrogen. Carbon monoxide reduces the blood's ability to supply oxygen. Those most at risk are infants, the elderly, and those having heart, lung, or anemic diseases. When oxides of nitrogen and sulfur mix with atmospheric moisture, the acid rain eventually produced can damage plants and aquatic life. Ozone aggravates allergies, asthma, and emphysema and impairs overall lung function. In Kansas, ozone is one of the key pollutants of concern associated with burning.

Because of the health and environmental risks associated with PM_{10}, $PM_{2.5}$, and ozone, both Kansas and the federal government have established standards to control ambient concentrations of these pollutants.

2.2 National Ambient Air Quality Standards

One of the goals of a smoke management plan is to ensure that all Kansas monitors meet the National Ambient Air Quality Standards (NAAQS). Should an area violate the NAAQS, measures must be taken to bring the area back into attainment. This section discusses the NAAQS and the costs associated with a violation of the NAAQS.

For the NAAQS, the EPA establishes two types of standards: "primary" standards to protect public health and "secondary" standards to protect public welfare, such as visibility impairment and damage to ecosystems. For many of the NAAQS pollutants, the two standards are identical for both annual and daily concentrations. The State of Kansas and EPA identify areas of the state which are attaining or not attaining the NAAQS. To complete this process, the state submits a formal request to EPA recommending which counties should be included in the area not attaining the standard. Compliance can be based on a county-by-county or a metropolitan statistical area (MSA) assessment of air quality.

2.2.1 Particulate Matter

The current EPA standard for PM_{10} is a daily standard with equal primary and secondary values (in $\mu g/m^3$), calculated as an arithmetic mean of three years of values. The daily standard is 150 $\mu g/m^3$, calculated as a three-year average with no more than one exceedance per year of measured samples. There are presently eleven PM_{10} monitors operating in Kansas. Most of these are in the Kansas City and Wichita metropolitan areas. Topeka has both continuous and filter-based PM_{10} monitors. Although there have been high hourly readings, monitoring data for Kansas has not shown violations of either the daily or the annual standards for total PM_{10}.

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The EPA issued a new standard for $PM_{2.5}$ effective December 18, 2006. The NAAQS for $PM_{2.5}$ has both an annual and a daily standard, with the primary and secondary standards set at the same value. The annual standard of 15 $\mu g/m^3$, calculated as the arithmetic mean of three years of values, was not revised. The daily standard was changed from 65 $\mu g/m^3$ to 35 $\mu g/m^3$, calculated as a three-year average of the 98th percentile of measured samples. Although there have been high hourly readings, monitoring data for Kansas has not shown violations of either the daily or the annual standards for total $PM_{2.5}$. There are presently 13 $PM_{2.5}$ monitors around the state that measure total mass. Ten of these are Federal Reference Method (FRM) PM monitors that sample one in three days. The remaining three monitors are continuous monitors. The map in Appendix A shows the location of all particulate matter monitors in Kansas.

2.2.2 Ozone

The current eight-hour standard for ozone is 0.075 parts per million (ppm). It took effect in 2008. The standard is calculated as an average of three years of the fourth highest value of the average of eight one-hour samples. However, the EPA proposed a new ozone standard on January 6th, 2010. The primary standard may be reduced to a range between 0.060 to 0.070 ppm, and a secondary standard may be adopted that evaluates the cumulative exposure to ozone based on 12 hour daily exposures for three months. A final rule is due in December 2010, with designation letters from the states submitted to EPA in 2011. There are presently nine ozone monitors in the state. The majority of these are in or near Kansas City or Wichita, with one in Topeka. Presently no monitor locations in the state exceed the existing 0.075 ppm ozone standard; however monitors in Kansas City, Missouri exceed the existing ozone standard.

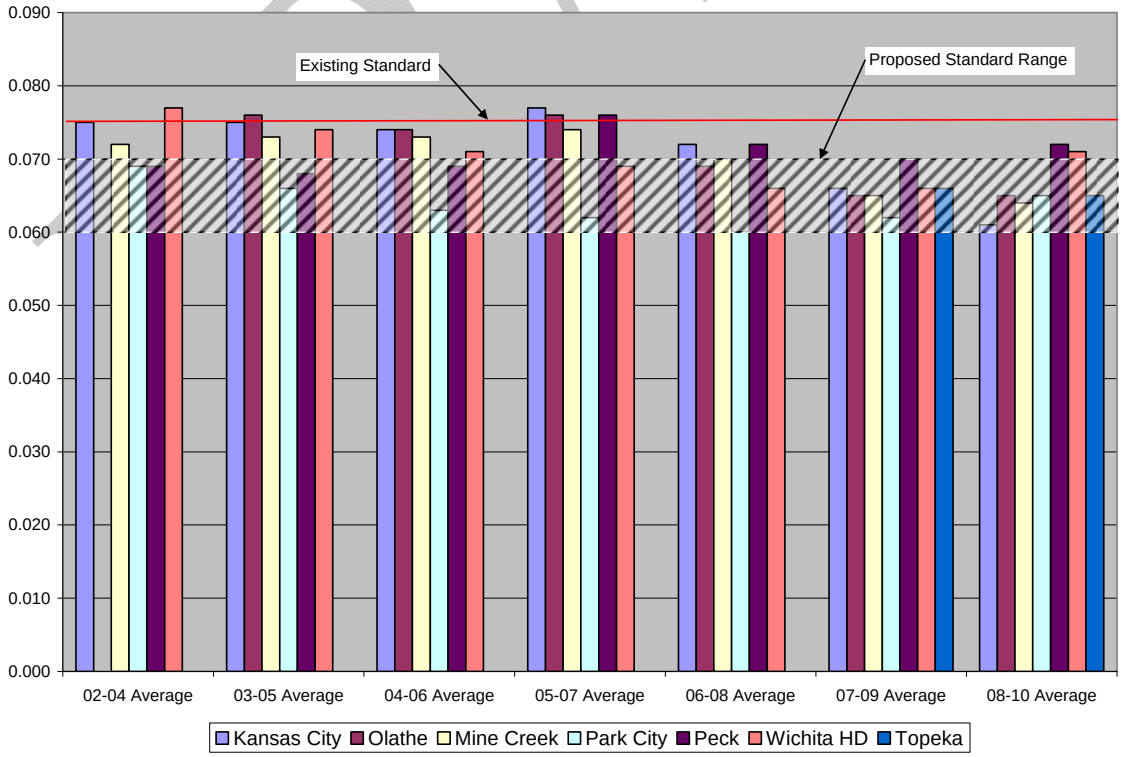

Figure 8. 4th High 8 hour ozone 3-year rolling average for Kansas Monitors

Since the entire Kansas City metropolitan area is designated in regards to attainment, this affects Kansas as well as Missouri. Although no monitors in Kansas currently violate the existing standard, Figure 8 shows that using 2008-2010 data, 2 monitors in the Wichita area would not meet the proposed standard. Burning in the Flint Hills caused exceedances of the ozone standard in Wichita for two of the three years of data used to generate Figure 8. Since the ozone standard is a 3 year average of the 4th high reading, these exceedances make it more difficult for Wichita to meet the ozone standard. The map in Appendix A shows the location of all ozone monitors in Kansas.

2.3 EPA Interim Policy and Guidance on Wildland and Prescribed Fires

The purposes of smoke management plans are "to mitigate the nuisance and public safety hazards (e.g., on roadways and at airports) posed by smoke intrusions into populated areas, to prevent deterioration of air quality and NAAQS violations, and to address visibility impacts in mandatory Class I Federal areas" (EPA 1998). The NAAQS referred to here are for particulate matter—$PM_{2.5}$ and PM_{10}.

According to the EPA's *Interim Air Quality Policy on Wildland and Prescribed Fires* (April 1998), "strong indications" that a SMP is necessary are the following:

1. Citizens increasingly complain of smoke intrusions;
2. The trend of monitored air quality values is increasing (approaching the daily or annual NAAQS for $PM_{2.5}$ and PM_{10}) because of significant contributions from fires managed for resource benefits;
3. Fires cause or significantly contribute to monitored air quality that is already greater than 85 percent of the daily or annual NAAQS for $PM_{2.5}$ or PM_{10}; or
4. Fires in the area significantly contribute to visibility impairment in mandatory Class I Federal areas.

EPA's Interim Policy and Guidance on Wildland and Prescribed Fires was written primarily to address particulate matter pollution. The four indicators that a smoke management plan is necessary do not generally apply to the air quality impacts associated with Flint Hills burning. However, the overall purpose of the Interim Policy, to prevent deterioration of air quality and NAAQS violations, is a primary goal of a smoke management plan. For ozone, especially with the continued lowering of the NAAQS, Flint Hills burning has been and continues to be a significant contribution to monitored exceedances of air quality standards. For example, in 2009, range burning was responsible for two of the highest of the four readings used to establish the yearly design value for the downtown Wichita area monitor (Wichita HD), while in 2010, emissions from burning were responsible for the highest ozone reading at this same monitor. Figure 9 shows the highest 8-hr ozone reading in the month of April across monitors in Kansas. From the figure it can be seen that ozone readings in April exceed the standard at numerous sites. Many of these elevated readings are a result of burning in the Kansas Flint Hills.

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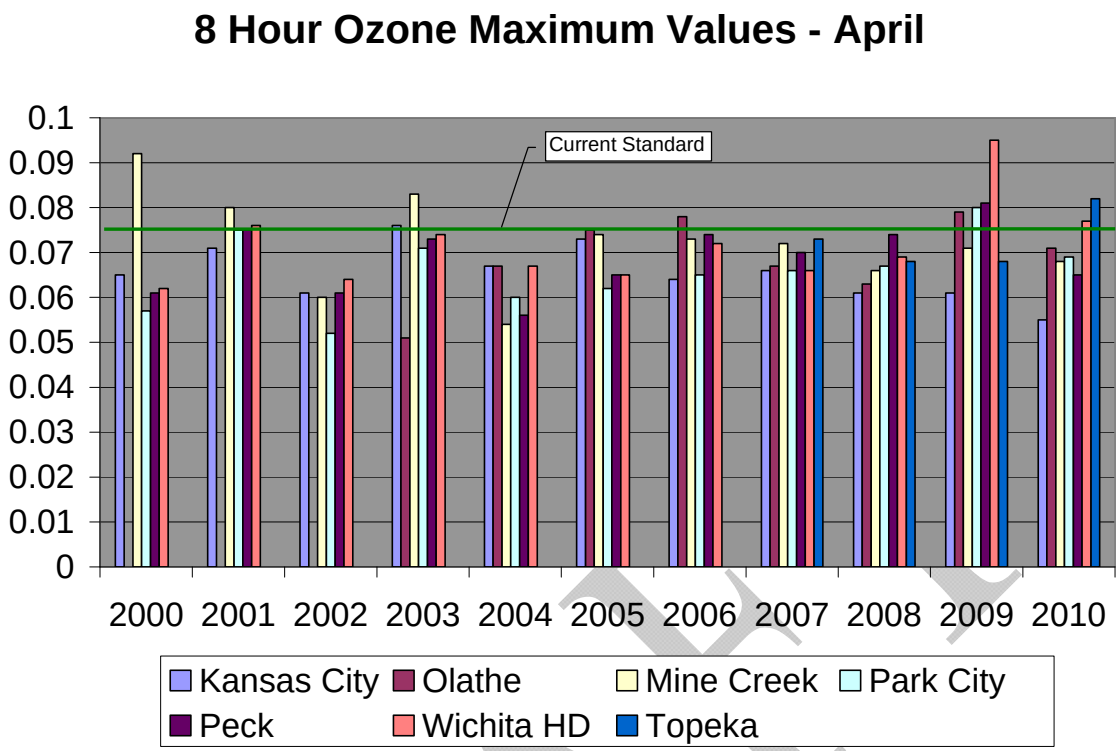

Figure 9. Maximum April 8-Hr ozone readings in Kansas (ppm) with current standard.

2.4 Nonattainment – Consequences and Costs

Should an area violate the NAAQS, certain measures must be implemented that mitigate the air quality problems. These measures can add regulatory burdens that curtail economic development and are costly. The majority of these control measures were implemented in Kansas City over the last 25 years and it could be expected that those implemented in any new nonattainment areas in the state would have a significantly higher cost. Some examples of regulatory burdens and measures associated with being designated nonattainment include:

- Specific rules targeting emissions reductions using Reasonably Available Control Technology (RACT). RACT rules impose requirements on certain industrial sectors that require control equipment, process changes, or material changes. These changes can be costly to implement and operate and may require additional reporting and recordkeeping. For example, the recent NO_x RACT rules that went into effect in the Kansas City area affected three facilities—two electric power plants and a glass manufacturer. These three facilities estimate a combined $50 million in capital expenditures for controls will be required to meet the new rules. There will also be additional costs in the future to operate and maintain these controls. Ultimately, these added costs are passed on the customers of these businesses, in this case in the form of higher electricity rates in the Kansas City area.

In the past, numerous Volatile Organic Compound (VOC) RACT rules were introduced into the Kansas City area including controls on bakeries, solvent usage, printing operations, surface coatings and gasoline service stations. A total of 16 VOC RACT rules have been adopted and implemented for Johnson and Wyandotte Counties.

In 2001, KDHE estimated the additional cost for a fuel with a lower vapor pressure would be 1.5 to 2.5 cents per gallon. Again, these costs directly affect the populations in the nonattainment areas.

- State implementation plans (SIPs) are needed to document measures on how an area intends to get back into attainment with the NAAQS and how it will maintain the NAAQS. Specific requirements include enhanced emission inventories, photochemical modeling, and additional planning. All of these activities have costs associated with them, including additional staffing at state and local agencies to perform the additional inventory, modeling, permitting, inspection, compliance, and public outreach activities. All of these costs are passed along to Kansas citizens in the form of higher taxes or added costs of the goods and services of the affected companies.

- Transportation conformity requirements must be met for emissions associated with transportation projects using federal dollars. Projects must be evaluated before construction and conform to an emission budget set as part of the SIP. Demonstrating conformity again takes both state and local resources. Projects that can't demonstrate conformity can not be undertaken.

- Loss of federal highway funds can be a result of failure to implement portions of the SIP. Federal highway funds can run into the 100's of millions of dollars for projects in nonattainment areas. A loss of these funds could be a major blow to the state or local region, and would affect construction-related employment along with the inconvenience of not having the completed projects.

- Other potential examples of specific rules targeting emission reductions could be inspection and maintenance programs (I/M) for all registered vehicles in an area, or reformulated fuels or low RVP fuels for certain areas. In February 2010, KDHE estimated the consumer costs of an I/M program in Johnson and Wyandotte Counties would be around $34 million annually.

2.5 Maintaining the Flint Hills and the Related Agricultural Economy

Since Euro-American settlement, fire has largely been suppressed in North American grasslands, contributing to range degradation due to woody encroachment. One exception is the extensive use of fire as a management tool by ranchers in the Flint Hills of Kansas and Osage Hills of Oklahoma. Residents here typically view fire as a necessary rangeland practice, whereas outside the region, the general attitude toward fire is often less

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favorable. Cattlemen recognized early on that burning Flint Hills pastures benefited cattle weight gains and the condition of their pastures. In the years following settlement, a significant portion of the Flint Hills (Figure 10) were burned on a frequent basis despite academic warnings against the practice, particularly in large pastures grazed by transient cattle. In the 1970s, range scientists began to promote the agricultural and ecological benefits of burning tallgrass prairie. At Kansas State University, range specialists encouraged frequent burning of tallgrass, and even annual spring burning coupled with intensive early stocking (IES; where roughly twice the numbers of yearling cattle are stocked during the first half of the grazing season). Today, range burning is widely prescribed by range specialists and ecologists alike as a management tool necessary to maintain the ecological integrity of tallgrass prairie. However, the cyclic scheduling of burns varies according to the objective of management practices.

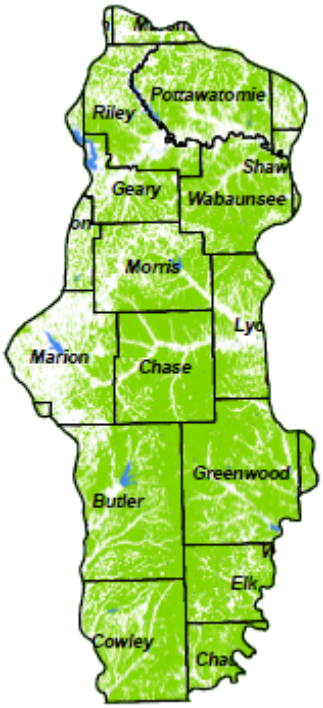
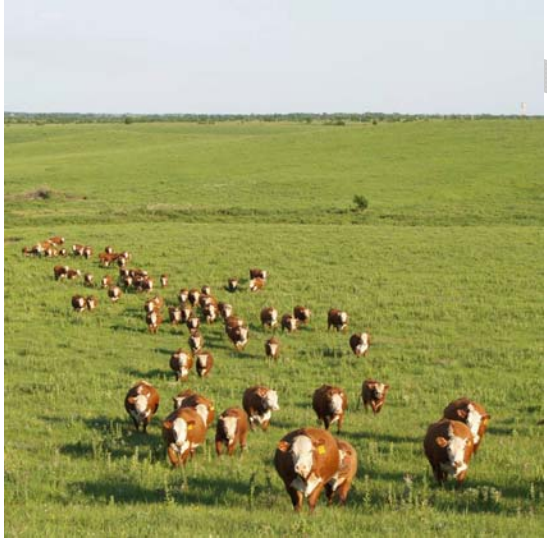


Figure 10. Flint Hills Counties.

Fire frequency varies widely depending on the type of livestock operation (e.g., cow-calf, season-long yearlings and short season stockers), but burning constraints, fire culture and historic land use also plays into the frequency of fire. One of the strongest motivators for land managers to burn is to improve daily weight gains in stocker cattle**,** which are commonly 10 to 15 percent higher in spring burned pastures (Vermeir and Bidwell 1998). Research at Kansas State University found that yearling cattle grazed on burned grasslands averaged 32 additional pounds of gain during the grazing season, compared to gains on unburned pastures. (Anderson, Smith, and Owensby. 1970. Burning bluestem range. J. Range Manage. 23:91-93; Owensby. 2010. Unpublished data). With today's (2010) market prices, these 32 pounds would result in an additional $32 per head, or an additional return of $8 to $16 per acre. While there is less animal performance benefit from burning pastures stocked by cow-calf herds, many land managers burn such pastures on a three-year fire-return interval to control woody plants and other undesirable species. However, tree infested pastures may require a higher fire-return interval (Brigg's paper). Land managed for conservation (e.g., Nature Conservancy preserves) also regularly burn to control woody vegetation and to enhance wildlife habitat. The frequency of burning varies with management practices but generally ranges between once every two to three years.



Historically, humid tallgrass prairies are thought to have burned primarily during the dormant season, particularly in autumn by Native Americans, but lightning-caused fires

were more common in mid to late summer. Contemporary pasture burning in the Flint Hills generally occurs in late March through early May, but early Flint Hills ranchers often burned even earlier to stimulate green up. Towne and Owensby (1984) reported that burning of ungrazed prairie in late-spring increased grass production and favored desirable warm season grasses, whereas winter and early- and mid-spring burns favored forbs and sedges. Launchbaugh and Owensby (1978) also found that the timing of burn had a significant impact on forage yields and animal performance. Yearling steers grazed on tallgrass prairie (near Manhattan, KS) that was burned later in the Spring (May 1)

gained 9.2 percent more than steers grazing pastures burned on March 20, and 3.2 percent more than steers grazing April 10 burned pastures. However, Towne and Kemp (2003) challenged the traditional perception that time of burn has a profound effect on vegetation because earlier studies lacked data with spatial or temporal variability. Instead, they found that average grass and forb biomass did not differ significantly in response to season of burn (November, February or April) after 8 consecutive annual burn treatments on two different topographic, unburned watersheds at Konza Prairie. It is important to note that these treatments were not grazed, and that vegetative responses due to timing of burn may differ in grazed tallgrass prairie.

There is a perception that most of the Flint Hills are intensively grazed and burned each year, but satellite imagery and Kansas Ag Statistics suggest these practices do not extend across the entire landscape. A draft analysis of satellite imagery from 2003 through 2006 indicates that about 1.67 million acres burned on average (range of 1.3 to 2 million acres) within 14 Flint Hills counties[2] (Doug Goodin, Kansas State University, unpublished

[2] Butler, Chase, Chautauqua, Coffey, Cowley, Elk, Geary, Greenwood, Lyon, Marion, Morris, Pottawatomie, Wabaunsee and Woodson counties.

data). This translates to 35 percent of total prairie acres burned, based on a 4.8 million acreage estimate within these counties[3]. However, the same satellite imagery revealed that certain areas of the Flint Hills, particularly the more intact areas of the landscape, were burned on a more frequent basis.

A paradigm to enhance heterogeneity in order to promote biological diversity and wildlife habitat on rangelands was proposed by Fuhlendorf and Engle (2001). One management practice used to enhance heterogeneity is patch-burn grazing (PBG). This fire-induced grazing regime is designed to approximate the natural interaction between fire and grazers. Typically, one-third of a PBG pasture is burned each year on a rotational basis. When only a portion of a pasture is burned, livestock focus most of their grazing in the burned patches. The result is an accumulation of vegetation in unburned areas, creating wildlife habitat and fuels for fires in subsequent years. The interaction of these disturbances produces a shifting mosaic of vegetative structure. PBG has been suggested as a way to reduce smoke emissions in the Flint Hills. However, its effectiveness for smoke reductions remains an open question. Even though only one-third of a pasture is burned each year under PBG management, two years of growth with minimal grazing is also being consumed in the burned patch. It is also important to recognize that some pastures in the Flint Hills may not be well suited to PBG because of the difficulty of maintaining fire breaks, and that the practice may require additional resources (fire equipment and manpower) to implement. PBG is also viewed by some as experimental, and may require additional research before it becomes a widely accepted practice.

Debate will continue regarding when and how often to burn tallgrass prairie; however, there is wide scientific consensus supporting the need for prescribed fire in native grasslands. One of the greatest threats to the tallgrass region is forestation due to fire suppression. Eastern redcedar, a species readily controlled with fire when trees are small, is rapidly increasing in coverage in Kansas, especially in the eastern half of Kansas. Redcedar and other invasive plant species targeted with herbicides can be managed more economically and with fewer ecologically impacts using prescribed fire.

Until only recently, certain areas of the Flint Hills, especially along the eastern and western flanks of the Flint Hills (e.g., southeastern Greenwood County), lacked a fire culture and seldom burned. As a result, many of these areas experienced heavy encroachment by woody vegetation, and are no longer able to support interior grassland species like greater prairie-chickens. At Konza Prairie, annual burning was the only fire treatment that reduced woody plant density, with rapid increases in woody encroachment for longer (≥4-year) fire-return intervals. Therefore, pastures with a high density of woody vegetation may need higher fire frequency than is currently practiced to reverse years of fire suppression. Annual burning may be less warranted in areas of the Flint Hills where woody vegetation is not a significant problem. Conversely, areas not receiving enough fire to keep ahead of woody encroachment may require burning consecutive years to reverse this trend.

To maintain and preserve the ecological integrity of tallgrass prairie, prescribed fire is a necessary management tool. Both plant and animal species depend on the positive effects

[3] 2005 land cover map was used to calculate percent native grasslands (non-CRP warm season) within a 1x1 mile grid. Only sections containing 40 percent or higher native prairie were used in the analysis.

of burning. Failure to regularly burn the Flint Hills will result in increasing losses of what remains of this last landscape of tallgrass prairie.

2.6 Summary

The reasons for having this plan are numerous. As a result of the continued exceedances of the ozone standard described earlier in this section, KDHE, EPA and the agricultural community agreed that a plan to reduce potential smoke impacts and address smoke emissions from the Flint Hills was good public policy and should be developed and implemented as soon as possible. The real and potential public health and economic impacts for both the urban and rural communities are substantial. All of the examples of additional requirements associated with nonattainment cost money to implement and are burdensome. Penalties for noncompliance can be extremely costly, running into hundreds of millions of dollars in the case of a loss of transportation funding. Ultimately it is Kansas citizens who pay for these costs of nonattainment, both with health impacts and monetarily.

Chapter 3. Reducing downwind impacts of Flint Hills burning

In this chapter we discuss the fire management practices (FMPs) that can be used to reduce the impacts of smoke before, during and after a burn. FMPs form the foundation of a good smoke plan along with information that will be made available via the Fire and Smoke Planning Resource website (http://www.ksfire.org). All of the FMPs discussed below require only 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 that will help ensure FMPs for air quality are being followed. The land manager should document and follow these FMPs whenever feasible to ensure their individual burns are minimizing the potential for adverse air quality.

3.1 Should I Burn This Year?

The first question that a land manager should answer is “Do I really need to burn to meet the objectives of land management?” This is an important question as the most obvious and effective method of smoke reduction is the use of a non-burning alternative or reducing the frequency of burns. For many land managers in the Flint Hills, a non-burning alternative is likely not available or cost effective due to the large acreages involved. Examples of non-burning alternatives for smaller pastures include spraying herbicides or physical removal of invasive woody species. However, reducing the frequency of the burns may be a viable strategy that still allows for management objectives to be met. If burning is required the land manager should strive to burn when the environmental conditions will minimize smoke concentrations that can become an air quality problem. These environmental conditions are described below with FMP guidelines.

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3.2 When Should I Burn?

Timing of prescribed burning activities should be driven by a specific objective, related to the desired vegetative condition or management goal and the timing of the prescribed burn activity should be scheduled providing for the greatest opportunity for success. 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 or fire. 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 impacted by prescribed fire after it has leaf emergence in late spring through the middle of the summer growing season. Land managers wishing to control cool season plants will most likely target a later prescribed burn date which provides greater opportunity to weaken established cool season plants while promoting vigor in desirable warm season species.

Both game and non-game avian species are also of consideration when prescribed burn timing is considered. Earlier prescribed burn activities (March) will benefit more flowering forbs and legumes throughout the early spring and summer. This timing is also important as it relates to nesting success due to adequate nesting cover as well as destruction of nests due to prescribed fire.

Land managers targeting animal performance as a primary objective typically will schedule prescribed burn activities around favored vegetative species which produce 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, giving 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 prior to 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.

3.3 Fire Management Practices (FMPs) for Air Quality Benefit

There are several burn practices that can help reduce impacts on air quality. Most techniques involve minimizing smoke production and 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

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air quality are not favorable for any reason the manager should consider rescheduling the burn to a different day. They will need to balance their need to burn with the potential air quality impacts their burning may have on downwind communities.

KDHE and Kansas State University have 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 the course of 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.

3.3.1 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 (http://www.airnow.gov/). If conditions are ideal for burning, there may likely be many fires going at once which can

Figure 11. NASA visible satellite image showing heavy smoke plumes across Eastern Kansas.

significantly degrade the air quality. Figure 11 is a NASA visible satellite image showing heavy smoke plumes originating from fires in the Flint Hills. If there is a lot of smoke already 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 different day when less burning is occurring.

3.3.2 Transport Wind

Land managers need to be aware of the impacts that both transport and surface winds have on air quality. Transport wind generally refers to the rate at which emissions 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 may also be described as the wind speed at the final height of plume rise. Wind direction is a key consideration as sensitive areas downwind of a burn should be considered before initiating the burn. The Fire and Smoke Planning Resource website or your local National Weather Service office will provide both the current and forecast wind speed and direction for your burn location. The contact information for Kansas National Weather Service offices is located in Appendix G. The VSMOKE tool found on the Fire and Smoke Planning Resource website provides a visual forecast of where the smoke plume will travel and its extent under the forecasted wind conditions. The VSMOKE tool was developed to predict downwind transport of pollutants but it does not include the mechanisms to predict ozone formation. The VSMOKE tool does provide the land manager with predictions on the movement of ozone precursors. It should be noted that 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 in a safe 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 high ozone precursor and PM concentrations. Winds that are too strong (greater than 15 mph) will cause dangerous burning conditions.

3.3.3 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 mixing height for the day of a prescribed fire by accessing the Fire and Smoke Planning Resource website or by contacting the National Weather Service. 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 during the burn are adequate to allow the smoke to rise away from the ground to disperse. Ideal mixing heights for burning generally occur during the day after the sun has adequately heated the ground, hence the ideal burning hours being

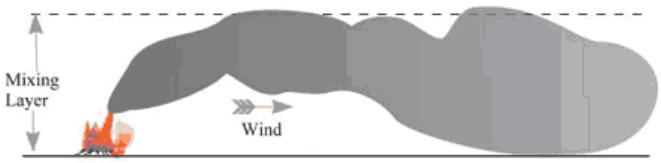

Figure 12. **POOR VENTILATION** - Winds are light and variable. Sounds carry a long way and it may be an overcast or foggy day. Stirred dust tends to hang around and linger. Smoke from fires tends to linger near the source or form a shallow trail that extends downwind.

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between two hours after sunrise to sunset. As the sun goes down, the mixing height will decrease which traps smoke in a thinner layer of the atmosphere increasing smoke concentrations (Figures 12-13). It is advised that burning should occur when mixing heights are 1800 ft. or higher.

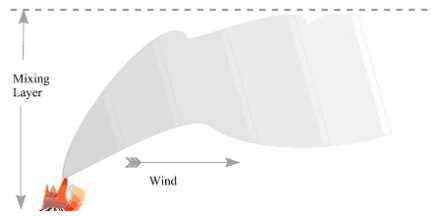

Figure 13. **GOOD VENTILATION -** Winds are 5 to15 mph without significant gusts, and wind direction is consistent. Clouds are high above the ground, indicating the mixing layer is deeper. Smoke rises quickly and/or disperses rapidly.

3.3.4 Timing

Timing of a burn can significantly impact the dispersion of smoke. It is advised that burning 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 from two hours after sunrise to ensure good atmospheric conditions exist.

3.3.5 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 will impact the efficiency of the burn creating more smoke and smoldering conditions. Ideal relative humidity conditions for favorable burning occur in the range between 30-50%. Higher air temperatures can lead to better combustion; however, ozone production is also increased 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 by contacting the National Weather Service.

3.3.6 Ignition and Burn Techniques

The type of prescribed fire (i.e. back fire, 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 like 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 will produce less smoke and reduce overall emissions. Smoldering is most often association with woody vegetation and denser canopy areas. Frequent burning results in less overall woody vegetation and therefore more rapid burn completion.

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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 tradeoffs 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. However, increased burning efficiency results in more NO_x and CO_2 in the smoke.

3.3.7 Other considerations

Cloud cover can also impact mixing heights and photochemistry. Cloudy skies prohibit the sun from hitting the ground which prevents the heating that is needed to produce good mixing heights. Cloud cover can actually help limit ozone formation due to the reduction in photochemical reactions when the sun is being blocked. However, total cloud cover is not conducive to good burn conditions, and thus burning under total cloud cover should be avoided. Some cloud cover coupled with adequate mixing could help limiting ozone formation. Ideal burning conditions for a good mixing height and reducing photochemical reactions occur with cloud cover between 30-50%. However, a good mixing height is the most important factor.

3.4 Smoke Plan Pilot Project

In order to assist land managers in the Flint Hills to implement the fire management practices in Chapter 3, a Smoke Plan document was developed and will be available as a form on the Fire and Smoke Planning Resource website or from the county extension agent. Greenwood and Chase Counties will pilot this program in the spring of 2011. Land managers in Greenwood and Chase Counties will be asked to participate in the pilot and fill out the form before they commence their burns. Participation in the pilot project will be voluntary. It is hoped that through good outreach and education of the benefits of this pilot program, there will be good participation.

3.5 Summary

Following the recommendations described above will help mitigate the impacts of smoke from prescribed fires. These recommendations are summarized in Appendix B and are incorporated into the FMP checklist in Appendix C. If conditions related to air quality are not favorable for any reason the manager should consider rescheduling the burn to a different day. They will need to balance their need to burn with the potential air quality impacts their burning may have on downwind communities.

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Chapter 4. April Burning Restrictions

Current burning regulations can be found in K.A.R 28-19-645, 28-19-646, 28-19-647 and 28-19-648. These current regulations on burning are found in Appendix D. These current regulations were drafted with primarily safety considerations in mind. As part of the Kansas Flint Hills Smoke Management Plan, KDHE will be drafting regulations that restrict burning activities in certain counties for the month of April only. These restrictions would include burning of materials such as land clearing debris, crop residues, construction debris, fire fighter training burns, yard waste, etc. Exemptions will be considered on a case-by-case basis for certain activities, storm debris being a good example of a burn activity that may likely qualify for an exemption. Burning that will continue to be allowed in these counties includes agricultural burning related to the management of prairie or grasslands, and conservation reserve program (CRP) burning activities. The proposed regulations will apply to 16 counties; Butler, Chase, Chautauqua, Cowley, Elk, Geary, Greenwood, Johnson, Lyon, Marion, Morris, Pottawatomie, Riley, Sedgwick, Wabaunsee and Wyandotte counties. Local authorities will be responsible for approving and enforcing burning activities in their respective jurisdictions. KDHE will provide guidance to local fire or emergency management authorities on the implementation of the April burning restrictions regulation including the conditions that warrant an exemption.

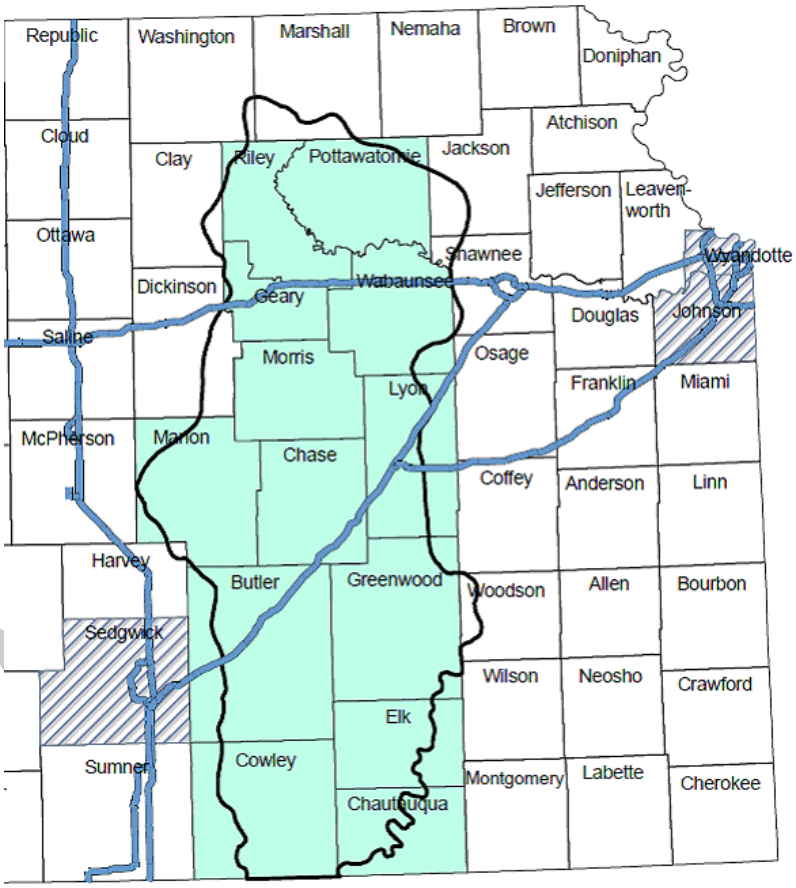

Figure 14. Map of 16 counties to be included in April Burning Restrictions

Figure 14 includes the 16 counties where certain burning activities will not be allowed during the month of April. All counties shaded will be subject to the April burn restrictions. Aqua shaded counties represent those in the heart of the Flint Hills where the majority of agricultural related prairie and grassland burning occur. Those counties with hashed shading represent metropolitan areas subject to the April burn restrictions. These metropolitan area counties represent the core of the cities that have been most severely affected by the Flint Hills burning since 2003.

Recognizing that this regulation will not be completed in time for the 2011 burn season, KDHE will engage the following organizations, Kansas Fire Marshall, Kansas Forest Service, Kansas Emergency Managers Association, Kansas State Fire Fighters Association, Kansas State University, and others to implement voluntary restrictions on burning in the 16 counties in April 2011. KDHE will inform these organizations of this request for assistance in implementing voluntary restrictions by speaking at meetings and conferences, submitting newsletter articles and direct contact through e-mail and phone calls. These contacts will also allow KDHE to receive feedback from these organizations during the April burning restrictions regulation development stage.

Chapter 5. Outreach, Education and Public Notification

5.1 Overview

Public education and awareness of the burning in the Flint Hills and the potential impacts that burning has on public health began in 2003. In 2003, air quality monitors that measure ozone in the Kansas City area recorded very high ozone readings on April 12 and 13. In the fall of 2003, KDHE staff presented information regarding the effects of the Flint Hills burning on ozone levels to agricultural interests at a conference at Kansas State University. KSU range management researchers, KSU Research and Extension, the Kansas Department of Agriculture, the Kansas Livestock Association, and other agricultural interests were all present at the meeting. With the help of the organizations present, KDHE planned to take an initial voluntary/educational approach to addressing the issue.

Since the fall of 2003, KDHE, Kansas State University (KSU) Extension and other agricultural organizations have met in the early spring before the Flint Hills burning commences and have coordinated the educational and outreach plan for that year. Numerous articles have been written in agricultural publications on the effects that smoke has on public health and ways to mitigate the smoke produced by burning the tallgrass prairie in the Flint Hills. Information on smoke management has been incorporated in all KSU Extension Safe Burn School curriculum. Safe Burn Schools, presented throughout the state, provide information about the use of prescribed fire as a range management method. Those in attendance included landowners, land managers, emergency personnel, and contractors offering burn services. In addition, smoke management messages have been incorporated in trainings and meetings such as the Kansas Emergency Managers Association meeting, Kansas State Fire Fighters Association wildfire training, and all Kansas Forest Service wildfire trainings.

Beginning in 2009, KDHE began issuing a yearly general "Air Quality Health Advisory" in March before the main burning of the Flint Hills begins. This advisory to the general public informs them of the important reasons for burning in the Flint Hills and of the potential health impacts that could be expected if these smoke plumes enter their areas. KDHE staff also monitors burning conditions throughout the months of March and April and beginning in 2010, if conditions are favorable for significant rangeland burning, a specific health advisory for the following days is issued.

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In order to effectively implement the Kansas Flint Hills Smoke Management Plan, a coherent program of outreach, education, and public notification will be conducted. Land managers, agencies, trade associations, and non-profit organizations with a stake in prescribed fire in Kansas will each use the resources they have available to promote adoption and implementation of the Kansas Smoke Management Plan.

Outreach and Education activities will effectively create, locate, consolidate, and present information in the appropriate formats necessary for successfully raising awareness and knowledge of the Plan and to achieve both regulatory and voluntary compliance. Information about the Plan will be broadly distributed and widely publicized. Activities will be coordinated whenever possible for maximum effect.

Information to be included in outreach and education activities include: the impacts of smoke from prescribed fires and the necessity of a plan; the Plan itself; explanation of how the plan is anticipated to work; the responsibilities of entities and individuals in implementing the plan; the process by which the Plan will be evaluated and modified as necessary; the reasons for prescribed fire, with emphasis on the necessity of prescribed fire for maintaining the ecological integrity of native rangelands; and actions taken by municipalities to protect citizens' health and attain air quality standards.

5.2 Outreach Methods

5.2.1 Predictive Model

A critical element of the outreach, education, and notification effort is having a qualified meteorologist run a modeling program on a daily basis during the burn season and inform the public of the predicted potential for air quality impacts in urban areas each day. This person would need to be recruited and trained prior to the burn season, and funding for this position must be found.

Daily model predications will be conveyed to decision-making agencies and the general public through websites, tweets, phone text messages, email distribution lists, or any combination of these. Outreach activities will include notifying stakeholders of the various ways in which the predictions can be accessed.

Land managers will be trained to use the prediction to correctly assess the probability of prescribed fires in their area contributing to air quality non-attainment in specified urban areas. Local decision makers will use the predictions, along with other factors, to permit or restrict prescribed fires within their jurisdiction on a specific day.

5.2.2 Formal Fire Instruction

Presentations and materials used in prescribed fire instruction will include discussion of the Plan and how to minimize the impacts of smoke on urban areas. Smoke management planning will be included as part of the curriculum at burn schools.

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5.2.3 Internet

Existing websites will create links to each other and to the newly developed Fire and Smoke Planning Resource website hosted by KSU, where relevant information relating to smoke management, the Plan and to its implementation will be posted. Success with this type of outreach is dependent upon having high-speed internet access available throughout rural areas of the state. Websites will need to be maintained to provide up-to-date information, especially immediately prior to and during the burn season.

5.2.4 Broadcasting

Information relating to the plan will be disseminated by interviews, public announcements, and incorporation into existing broadcasting schedules. During the burn season, daily updates about smoke management predictions will be provided to radio and television stations to include as part of their morning weather reports.

5.2.5 Print

Brochures, newsletter articles, posters, flyers, and press releases will be used to notify and inform the public about the Plan and its implementation. Promotional materials will be prominently displayed wherever possible to increase awareness and to provide direction to obtaining additional, more specific information.

5.2.6 Group Presentations

Workshops, coffee-shop talks, conference presentations, and other informational meetings will be used to provide materials and training about the Plan and its implementation to attendees. A standardized slide show about the Plan will be produced and made widely available.

Whenever possible, discussion of the Plan should be incorporated into staff and organizational meetings or other routinely scheduled events involving environmental, natural resource, and land management personnel.

5.3 Audiences and Message Content

5.3.1 Land Manager

Land managers who conduct prescribed fires will be informed of the Plan and of the necessity of their participation in implementing the plan. Numerous methods of communication will be used to emphasize the importance of conducting prescribed fire activities in a manner that is most likely to achieve smoke management goals.

Land managers will be trained to find and interpret seasonal and daily updates about anticipated burning conditions in order to allow planning and executing prescribed fires in accordance with the Plan. Any new activities required to comply with the plan will be clearly and thoroughly explained through workshops and one-on-one with agency personnel well in advance of the burn season, allowing adequate time for preparing additional documents or collecting necessary information.

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5.3.2 Agency (including municipalities)

Agencies and organizations who will be affected by the plan or whose constituency will be affected will inform their staff and stakeholders about the Plan and the effect of its implementation upon agency activities. Changes will be made to existing programs and procedures to improve compliance with the Plan. Key personnel within each agency will be identified as the primary contacts and conduits for Plan training and information.

5.3.3 Regulatory

Regulatory changes and expectations that will affect implementation or modification of the plan will be provided by state and federal agencies well in advance of implementing any regulation. Information about potential changes and the necessity for these changes will be widely distributed and a mechanism for feedback and modification provided prior to implementing the changes. Outreach, education, and notification efforts will accompany any changes.

New or refined scientific information about prescribed fires and smoke management will be conveyed to state and federal agencies to assist them in their decision making and Plan implementation evaluation.

5.3.4 Businesses

Businesses whose activities will be affected by Plan implementation will be identified and contacted by letter or email to inform them of the changes desired or required to reduce smoke production during the peak prescribed fire period.

5.3.5 Public

Citizens who may be affected by the smoke produced by prescribed fires will be notified of the smoke Plan and the reasons for prescribed fires. The availability and interpretation of health advisories that will be provided during probable smoke events to reduce exposure and associated health impacts will be widely publicized through mass media and medical venues.

5.4 Education and Outreach Workgroup

Agencies and stakeholders that participated in the development of this SMP will be invited to participate in a workgroup to implement this section of the plan. Lead agencies will be KDHE and KSU. This workgroup will begin their work immediately after the completion of this plan.

Chapter 6. Surveillance and Enforcement

The majority of this plan is voluntary. Surveillance of the plan will be accomplished in several ways. Air monitoring information and remote sensing data from satellites will be gathered and evaluated during the burning season. In addition, post burn season surveys will be conducted to evaluate the effectiveness of the public outreach and effectiveness of the April burning restrictions.

Enforcement of existing regulations related to agricultural burning is primarily handled by local fire and emergency management personnel. This plan is structured to continue

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this procedure. Local emergency management officials and the KDHE District offices will monitor compliance with the April burning restrictions regulation. KDHE has the authority to enforce against violations pursuant to K.S.A. 65-3005.

Chapter 7. Data Collection, Research Needs and Long Term Strategies.

7.1 Data Collection

7.1.1 Data Collection Pilot Program

The need to get better documentation, in a timely manner, on the number of acres burned in a season in the Kansas Flint Hills was identified as a significant need to supplement the SMP. Currently each county has differing levels of reporting procedures and gathering of this information. Some counties do not require any notification at all of a landowner's intent to burn; others require notifications and gather several pieces of information. Currently the only estimates of how many acres have burned are derived from satellite imagery.

The goal of the pilot program is to develop a centralized reporting system that would make this information not only more accurate but also timelier, while protecting landowner and/or prescribed fire practitioner privacy.

The appropriate fire, law enforcement, or emergency management official in nine pilot counties in the Flint Hills were contacted. These officials were asked if they currently asked for Prescribed Fire Practitioners to call in their intent to burn and to call back when they are done with the burn. Those that did not currently ask for practitioners to call back when they were done said that they would begin to do so. All of the officials were asked to begin to collect, document, and pass on to a centralized online reporting form the information. No landowner or specific location information will be passed on in the form; each county will compile all the burn information for a month into a single, county wide report for each month. Butler, Chase, Coffey, Geary, Greenwood, Morris, Pottawatomie, Riley and Wabaunsee counties have been selected as the pilot counties for this effort.

This form will be automatically emailed to a Kansas Forest Service Fire Staff member once per month, who will pass on the information to the KDHE.

7.2 Research Needs

7.2.1 Characterize emissions associated with Flint Hills burning

Additional research is needed to characterize the particulate and ozone precursor emissions associated with burning in the Flint Hills. Emissions can vary with different burning techniques, fuel conditions, fuel loading, meteorological conditions, burn timing, etc. Particular areas of interest include a better characterization of ozone precursor emissions under different burn conditions. Research should be coupled with remote sensing data for characterization of fuel loading if possible.

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7.2.2 Using remotely sensed data for fuel biomass loading

Because emissions are strongly associated with the amount of fuel being burned it is important to accurately characterize the amount of fuel being burned. Fuel loading in the flint hills can vary widely and depends heavily on management practices, growing conditions, timing of burn, location of burn, etc. Accurately characterizing the fuel loading on the day (or week) of a burn could have a large impact on the predicted emissions associated with the burn. Currently KDHE and EPA estimates assume a static fuel loading throughout the entire Flint Hills area. Using remote sensing for fuel loading would greatly improve our understanding of the potential impacts burning could have on air quality, with potential benefits in both forecasting and retrospective analysis of fire events.

7.2.3 Monitoring Studies

Monitoring of air quality during fire events is necessary to improve our understanding of the pollutants associated with fires. Monitoring information can be used in numerous ways including for inputs to air quality models, validation of air quality models, characterization of air quality (NAAQS), in health studies, for evaluation of the SMP effectiveness, for public notification, to characterize air quality trend levels, etc. Additional monitoring for ozone precursor pollutants could also be used to validate emissions factors and/or biomass loading research proposed above.

7.2.4 Timing and frequency of burns

Additional research on the both the benefits and problems associated with burn timing needs further investigation. Research should include characterization of ecological and economic response to both early and late season burn timing and further characterizing the potential agricultural economic benefit/disbenefit of burn timing. Of particular importance is characterizing impacts than burn timing has on native plant and animal species in the Flint Hills and agriculture production response, including cost, associated with different production/stocking techniques.

7.2.5 Management techniques

Different land management techniques can be used depending on the objective of the land manager. For example, patch burning, where a section of land is burned on a rotating basis to move grazing, could impact the emissions associated with burning, wildlife habitat, management costs, livestock weight gain, soil and nutrient conditions, vegetation benefits/disbenefits, etc. The air quality implications of various management practices should be further investigated while characterizing how these various practices can impact other important aspects of the Flint Hills ecosystem and agricultural economics of land management.

7.2.6 Health Impacts

KDHE, in conjunction with the Center for Disease Control (CDC), participated in an initial study to investigate emergency room visits and hospital admissions associated with respiratory conditions during the following periods; pre-burn, during burning, and post burn. KDHE is currently in discussions with CDC to develop a more comprehensive study on the potential health impacts of the burning in the Flint Hills.

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7.2.7 Burning Affects on Prairie Chicken Populations

Additional research on the both the benefits and problems associated with burn timing and frequency on the Greater Prairie Chicken population in the Flint Hills needs further investigation.

7.3 Long Term Strategies

7.3.1 Modeling

Over the past few years many tools have become available that allow for better identification, characterization, and prediction of air quality related to fires. Remote sensing tools that allow for real time identification of fires are now available leading to data products such as SMARTFIRE. SMARTFIRE characterizes both burn location and size on a daily basis from satellite data. This remote sensed data can be coupled with other models that estimate biomass burned to characterize emissions. From there you can take meteorological data and estimate with a photochemical model where smoke related emissions will travel and what their impacts on air quality will be. All of these tools are currently available and in use today in other areas.

These tools can be customized for predicting the impacts of fires in the Flint Hills, both for predictive purposes and retrospective analysis of past events. For example, in order to accurately predict ozone in an urban setting you need a fairly fine resolution grid (4km or less) that accounts for emissions and meteorological conditions. It would be possible to set up a modeling system with a fine domain over the eastern portion of Kansas that could characterize the emissions from Flint Hills burning on a daily basis at a 4km resolution. This data could then be fed into a photochemical model that would provide a prediction of both $PM_{2.5}$ and ozone concentrations from the burning. This information could be used to issue forecast warnings to affected locations.

These models can also be used for a near-term forecast of the impacts of burning. These forecasts would incorporate not only the recent (past day or two) burning, but would also attempt to forecast air quality based on various burn forecasts. This information could be used by land managers and decision makers to determine whether burning should occur and to what extent it could occur without causing air quality exceedances in sensitive areas.

Retrospective analysis of prior burn events that have been associated with air quality problems can also be done with these modeling tools. This type of analysis can help answer questions such as how much burning could have occurred under these meteorological conditions without causing an air quality problem, or could burning have occurred in a certain location but been curtailed in another location to mitigate the air quality problems. Answering these types of questions using this type of analysis can guide decision makers and land managers to implement burn practices that minimize air quality problems while retaining the needed burning for management purposes.

These modeling tools are available now and are continually being improved. With the continued computational resources becoming available at lower costs it is becoming

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easier and cheaper to do these forecasts and predictions near real time. Having this ability could greatly improve the decision making associated with burning in the Flint Hills and could minimize air quality impacts. With the continued lowering of NAAQS along with additional areas of concern, it is imperative these tools are utilized to improve the decision making process moving forward.

KDHE recommends that ongoing research be used to evaluate and improve upon this SMP. As part of this recommendation, computing equipment and staff will need to be available and funded. Costs for this research are estimated at 150K per/year, with an additional upfront cost for computing hardware of 50K in the first year. This equipment and staff could also be used to provide forecast information annually to the land managers during the burning season. The remaining portion of the year when forecasts are not needed would be used to further develop techniques for improving forecasts and for retrospective analysis of past forecasts and decisions. Once a modeling system has been fully developed and is functional, annual funding could be scaled back.

Chapter 8. SMP Evaluation and Contingency Measures

8.1 Introduction

Evaluation of the effectiveness of the SMP is a key component of ensuring the plan is having the intended goal of reducing the adverse air quality impacts associated with burning in the Flint Hills. Evaluation of the plan will be ongoing with input from all stakeholders, including land managers, EPA, environmental groups etc. It is anticipated the plan will change as more is learned about Flint Hills burning and its impacts on air quality. This document is intended to be a living document that will be modified as new research is conducted or new NAAQS take affect. The ultimate goal of the SMP is to avoid exceedances of the NAAQS. Should the NAAQS be exceeded due to Flint Hills burning, KDHE will initially seek EPA approval to exclude data and will evaluate the need to follow up with plan modifications to avoid further exceedances.

8.2 Technical Information Gathered During Burn Season

In order to evaluate the plan, air monitoring information will be evaluated during the burning season. The pollutants of concern include ozone, $PM_{2.5}$, PM_{10} and NO_x. Monitoring data from the existing KDHE network and meteorology information such as temperature, humidity, wind speed and direction, cloud cover, mixing height, temperature inversions, along with remote sensing data from satellites to locate and track smoke plumes and estimate acres burned will be collected.

8.3 Post Burn Season Report

After each burn season, KDHE will examine and share with EPA, KSU and stakeholders the air monitoring data, satellite imagery, and meteorological conditions to determine if Flint Hills burning contribute to any NAAQS exceedence. A report on the findings will be posted to the KDHE and Fire and Smoke Planning Resource web sites. KDHE will request comment on whether changes or improvements to the SMP are needed.

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8.4 Land Manager Survey

Part of the evaluation of the SMP will be a land manager survey that identifies the effectiveness of public outreach. In addition, the April burning restrictions effectiveness will be evaluated with a survey of local agencies implementing and enforcing the restrictions. Questions such as the following will be used to identify the effectiveness of the plan:

- Was land manager aware of SMP, and if so, how did they find out about it?
- Were burn practices modified?
- Likelihood of following SMP next season?

8.5 Contingency Measures

An effective evaluation of the plan will likely require multiple years of air quality data due to the many uncontrollable variables that occur when burning in Flint Hills. These variables include temperature, wind speed and direction along with weather patterns. If the technical evaluation demonstrates that Flint Hills burning caused or significantly contributed to exceedances of the ozone or particulate matter standards, KDHE will schedule a meeting or conference call to review the data and reach a consensus on whether to implement contingency measures. If the technical evaluation demonstrates that Flint Hills burning caused or significantly contributed to a violation of either air quality standard, KDHE will convene a meeting or series of meetings to determine appropriate contingency measures to implement to help maintain the NAAQS. As the plan is evaluated and improved with modifications, contingency measures can be implemented that will help further reduce impacts of burning on air quality. These contingency measures are discussed below.

This smoke management plan relies heavily upon education and outreach. For the SMP to be effective in reducing emissions affecting air quality, land managers will need to use the available tools and adopt the FMP's. If the SMP is not effective enough to prevent an exceedance of the NAAQS, then certain contingency measures will need to be considered. The following contingency measures have been identified and could be implemented to help achieve additional emission reductions related to burning. These measures are in no particular order, and one or more could be selected should smoke from Flint Hills burning continue to cause air quality problems. This list of measures is not exhaustive, future research efforts may demonstrate that other measures not included on this list would prove beneficial in reducing air pollutant emissions from the Flint Hills burning. These new measures, once identified, will be evaluated for inclusion in the potential contingency measures.

- April Burning Restrictions
    - The SMP currently calls for KDHE to enact a regulation that restricts burning during April for all counties in the Flint Hills ecoregion, as well as Sedgwick, Johnson, and Wyandotte counties.

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- *Contingency Measure*: The burning restrictions during April could be extended to those counties immediately outside of the Flint Hills ecoregion. Additional counties from the Wichita and Kansas City metropolitan statistical areas could also be included.

- Smoke Plans
  - The SMP currently has a voluntary plan in two pilot counties.
  - *Contingency Measure*: The scope and county coverage of smoke plans could be increased.
    - Step 1 –Smoke plans would become voluntary in additional (or all) Flint Hills counties
    - Step 2 - Smoke plans could become required in some (or all) Flint Hills counties.

- Notification and data collection
  - The SMP currently does not mandate notification and data collection.
  - *Contingency Measure*: Notification and data collection could become a requirement.

- Burn Approvals
  - The SMP does not require burn approvals at this time. Ten counties[4] within the Flint Hills ecoregion require burn approvals in the form of a permit.
  - *Contingency Measure*: Burn approvals/permits could be required, based on meteorological and pre-existing conditions.
    - Step 1 - Only in targeted counties with large number of acres burned.
    - Step 2 - All counties in Flint Hills ecoregion

- Time of day window
  - Currently, the SMP discourages nighttime burning. K.A.R. 28-19-647 does not allow for initiation of nighttime burning for any permit issued by KDHE.
  - *Contingency Measure*: Starting and ending times for burning could be established in accordance with local weather conditions. A nighttime burning ban could be extended to all Flint Hills counties.

- Burn ban days

[4] Counties of Butler, Geary, Jackson, Lyon, Pottawatomie, Riley, Shawnee, Wabaunsee, Washington, Woodson

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- Currently, the authority to issue burn bans lies with the Governor.

- *Contingency Measure*: The authority to issue a burn ban could be expanded to include the Secretary of KDHE. Open burning could be banned on certain days in which air quality could be severely impacted. A small advisory group of state and local officials (KDHE, NWS, KSU, etc.) could be tasked to work on daily ban recommendations to the Secretary and/or Governor.

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Appendix A - Ozone, PM_{10} and $PM_{2.5}$ Monitoring Locations in Kansas

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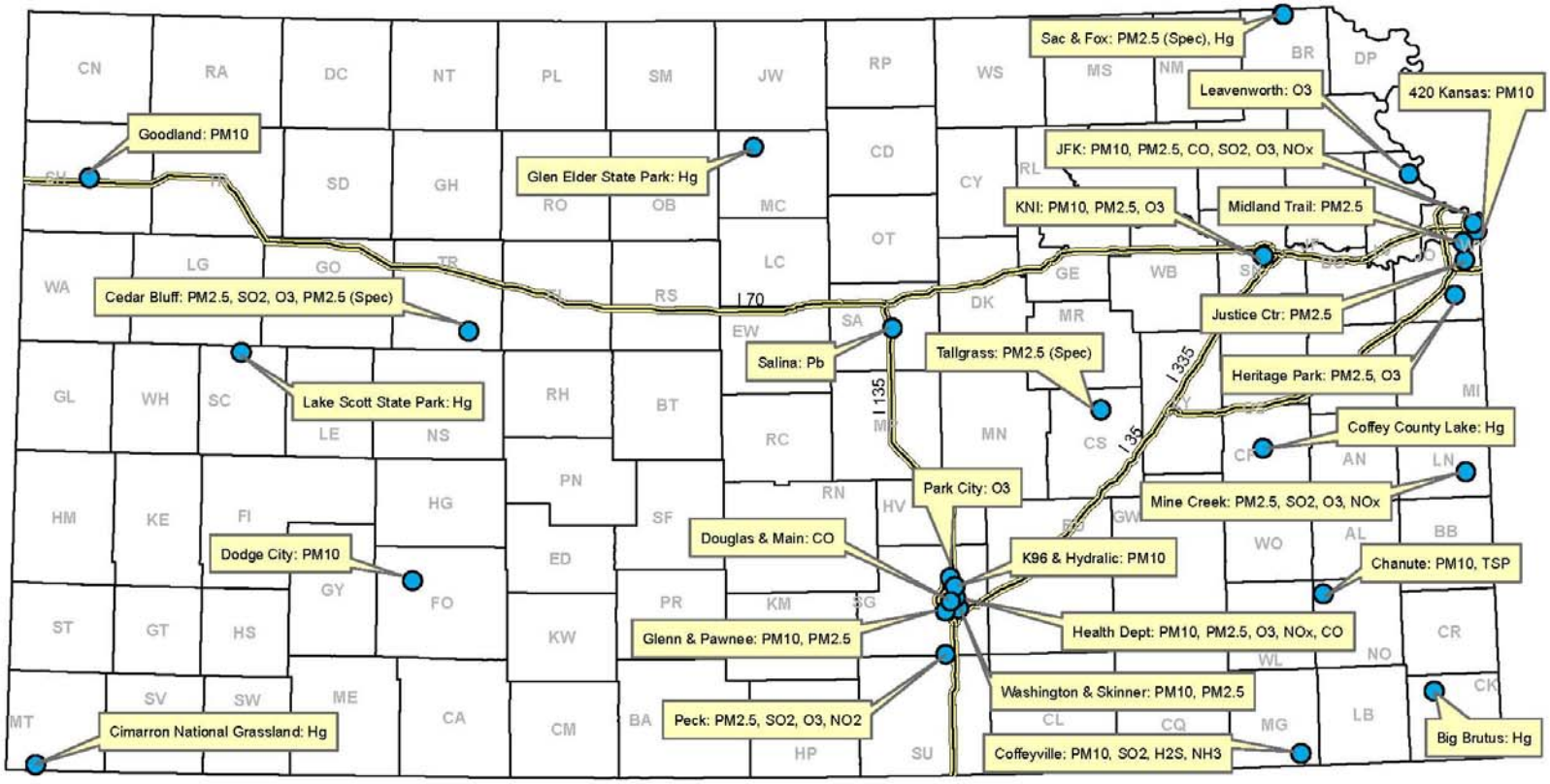
Kansas Air Monitoring Sites, January 2010



Appendix B – Meteorological Conditions for Smoke Dispersion

•Mixing Height
Minimum 1800'(548m)

•Transport Winds
8-20 mph (7-17 knots)(3.6-8.9m/s)
(1mph = .868 knots)
(1mph = .447m/s)

•Relative Humidity
30-55%

•Preferred Start/Stop Times –10am to 6pm

•Cloud cover –30-50% (reduced ozone production)

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Appendix C – 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, proposed dates of burns
- Objectives of the prescribed fires – forage improvement (yield, quality), weed/brush control (target weeds – recommended timing), wildlife habitat enhancement, CRP contract requirements
- Site characteristics – fuel condition (moisture, loading, type), soil moisture, 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 web site (http://www.ksfire.org). It is also recommend that a test fire be used to ensure the conditions are favorable for burning.

- Time fire started _____
- Wind Speed _____
- Wind Direction _____
- Relative Humidity _____
- Air Temperature _____
- Cloud cover _____
- Trans. Wind Speed _____
- Mixing Height _____
- Soil Moisture _____(saturated, moist, dry)
- Fuel Moisture _____(moist, dry)

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- VSMOKE Model Run _____ yes _____ no
- 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, other)

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

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Appendix D - Current Regulations on Burning

OPEN BURNING RESTRICTIONS

28-19-645. Open burning prohibited.
A person shall not cause or permit the open burning of any wastes, structures, vegetation, or any other materials on any premises except as authorized by K.A.R. 28-19-647 and K.A.R. 28-19-648. (Authorized by K.S.A. 1994 Supp. 65-3005; implementing K.S.A. 1994 Supp. 65-3005, K.S.A. 65-3010; effective March 1, 1996.)

28-19-646. Responsibility for open burning.
It shall be prima facie evidence that the person who owns or controls property on which open burning occurs has caused or permitted the open burning. (Authorized by K.S.A. 1994 Supp. 65-3005; implementing K.S.A. 1994 Supp. 65- 3005, K.S.A. 65-3010; effective March 1, 1996.)

28-19-647. Exceptions to prohibition on open burning.
(a) The following open burning operations shall be exempt from the prohibition on the open burning of any materials imposed by K.A.R. 28-19-645:

(1) open burning carried out on a residential premise containing five or less dwelling units and incidental to the normal habitation of the dwelling units, unless prohibited by any local authority with jurisdiction over the premises;

(2) open burning for cooking or ceremonial purposes, on public or private lands regularly used for recreational purposes;

(3) open burning for the purpose of crop, range, pasture, wildlife or watershed management in accordance with K.A.R. 28-19-648; or

(4) open burning approved by the department pursuant to paragraph (b).

(b) A person may obtain an approval from the department to conduct an open burning operation that is not otherwise exempt from the prohibition imposed by K.A.R. 28-19-645 if it is demonstrated that the open burning is:

(1) necessary, which in the case of burning for the purpose of disposal of any materials, shall mean that there is no other practical means of disposal;

(2) in the public interest; and

(3) is not prohibited by any local government or local fire authority.

(c) Open burning operations for which an approval is required but which are deemed to be necessary and in the public interest include the following:

(1) the use of safety flares for disposal of flammable gases;

(2) fires related to the training of government or industrial personnel in fire fighting procedures;

(3) fires set for the removal of dangerous or hazardous liquid materials;

(4) open burning of trees and brush from nonagricultural land clearing operations; and

(5) open burning of clean wood waste from construction projects carried out at the construction site.

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(d) Each person seeking an approval to conduct an open burning operation pursuant to this regulation shall submit a written request to the department containing the following information:

(1) the location of the proposed open burning and the name, address and telephone number of the person responsible for the open burning;

(2) a description of the open burning including:

(A) the estimated amount and nature of material to be burned;

(B) the proposed frequency, duration and schedule of the burning;

(C) the size of the area to which the burning will be confined;

(D) the method of igniting the material;

(E) the location of any public roadways within 1,000 feet of the proposed burn;

(F) the number of occupied dwellings within 1,000 feet of the proposed burn; and

(G) evidence that the open burning has been approved by appropriate fire control authority having jurisdiction over the area; and

(3) the reason why the proposed open burning is necessary and in the public interest if the activity is not listed in subsection (c) of this regulation.

(e) Each open burning operation for which the department issues an approval pursuant to paragraph (b) shall be subject to the following conditions, except as provided in paragraph (f):

(1) The person conducting the burning shall stockpile the material to be burned, dry it to the extent possible before it is burned, and assure that it is free of matter that will inhibit good combustion.

(2) A person shall not burn heavy smoke-producing materials including heavy oils, tires, and tarpaper.

(3) A person shall not initiate burning during the nighttime, which for the purposes of this regulation is defined as the period from two hours before sunset until one hour after sunrise. A person shall not add material to a fire after two hours before sunset.

(4) A person shall not burn during inclement or foggy conditions or on very cloudy days, which are defined as days with more than 0.7 cloud cover and with a ceiling of less than 2,000 feet.

(5) A person shall not burn during periods when surface wind speed is less than 5 mph or more than 15 mph.

(6) A person shall not burn within 1,000 feet of any occupied dwelling, unless the occupant of that dwelling has been notified before the burn.

(7) A person shall not conduct a burn that creates a traffic or other safety hazard. If burning is to take place within 1,000 feet of a roadway, the person conducting the burn shall notify the highway patrol, sheriff's office, or other appropriate state or local traffic authority before the burning begins. If burning is to take place within one mile of an airport, the person conducting the burn shall notify the airport authority before the burning begins.

(8) The person conducting the burn shall insure that the burning is supervised until the fire is extinguished.

(9) The department may revoke any approval upon 30 days notice.

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(10) A person shall conduct an open burning operation under such additional conditions as the department may deem necessary to prevent emissions which:

(A) may be injurious to human health, animal or plant life, or property; or

(B) may unreasonably interfere with the enjoyment of life or property.

(f) The department may issue an approval for an open burning operation that does not meet the conditions set forth in subsection (e) upon a clear demonstration that the proposed burning:

(1) is necessary and in the public interest;

(2) can be conducted in a manner that will not result in emissions which:

(A) may be injurious to human health, animal or plant life or property; or

(B) may unreasonably interfere with the enjoyment of life or property; and

(3) will be conducted in accordance with such conditions as the department deems necessary.

(Authorized by K.S.A. 1994 Supp. 65-3005; implementing K.S.A. 1994 Supp. 65-3005, K.S.A. 65-3010; effective March 1, 1996.)

28-19-648. Agricultural open burning.

(a) Open burning of vegetation such as grass, woody species, crop residue, and other dry plant growth for the purpose of crop, range, pasture, wildlife or watershed management shall be exempt from the prohibition on the open burning of any materials imposed by K.A.R. 28-19-645, provided that the following conditions are met:

(1) the person conducting the burn shall notify the local fire control authority with jurisdiction over the area before the burning begins, unless the appropriate local governing body has established a policy that notification is not required;

(2) a person shall not conduct a burn that creates a traffic safety hazard. If conditions exist that may result in smoke blowing toward a public roadway, the person conducting the burn shall give adequate notification to the highway patrol, sheriff's office or other appropriate state or local traffic control authorities before burning;

(3) a person shall not conduct a burn that creates an airport safety hazard. If smoke may affect visibility at an airport, the person conducting the burn shall give adequate notification to the appropriate airport authorities before burning; and

(4) the person conducting the burn shall insure that the burning is supervised until the fire is extinguished.

(b) Nothing in this regulation shall restrict the authority of local jurisdictions to adopt more restrictive ordinances or resolutions governing agricultural open burning operations.

(Authorized by K. S.A. 1994 Supp. 65-3005; implementing K.S.A. 1994 Supp. 65-3005, K.S.A. 65-3010; effective March 1, 1996.)

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Appendix E - Education and Outreach Activities

Activity	*Reason for activity and message to be conveyed*	*Target Audience(s)*	*Number of times activity will occur before next burn season*	*Could this activity be presented collaboratively with other organizations (Y or N)*	*Type of Materials Needed*	*Could this material be generated in a format for use by organizations other than your own? (Y or N)*	*Additional Clarification*	*Organization*
Update targeted list of members (land managers) on status and aspects of draft smoke mgmt plan (KLA working group)	Informing ranchers and landowners in Flint Hills of importance to rely on smoke management plan when planning prescribed fires.	Land Managers (25)	1	Y	Handout	Y	This working group represents several land managers with large acreages.	KLA
Report to members (land managers) on provisions of new smoke management plan	Informing ranchers and landowners in Flint Hills of importance to rely on smoke management plan when planning prescribed fires.	KLA members in Flint Hills counties	Estimate of 10 meetings	Y	Handout & power point presentation	Y	Staff reports to members at Flint Hills county meetings of KLA and Annual Mtg.	KLA
Inclusion of smoke management plan provisions, web site links, and related information.	Informing ranchers and landowners in Flint Hills of importance to rely on smoke management plan when planning prescribed fires.	KLA members and nonmembers accessing KLA web site.	1	Y	narrative summary	Y	KLA website includes several links and documents of management topics.	KLA

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Activity	***Reason for activity and message to be conveyed***	***Target Audience(s)***	***Number of times activity will occur before next burn season***	***Could this activity be presented collaboratively with other organizations (Y or N)***	***Type of Materials Needed***	***Could this material be generated in a format for use by organizations other than your own? (Y or N)***	***Additional Clarification***	***Organization***
Reminder of smoke management plan in weekly newsletter	Informing ranchers and landowners in Flint Hills of importance to rely on smoke management plan when planning prescribed fires.	All KLA members	2	N	narrative summary	Y	Weekly newsletter in pre-burn season could serve as a timely reminder of smoke management plan.	KLA
Promotion/awareness of the KS smoke mgmt plan through internal pubs radio programming, KFB events and meetings and media interviews	Need for our members to understand the requirements and implications for their operations	KFB members	20-Oct	Some of it	The plan and a summary of the expectations	Yes		KFB
Sponsor meetings & workshops	Work with various entities that burn in April to limit those burns	Parks managers, fire districts, utilities, private land owners, land clearing contractors, city/county codes	Uncertain	Y	KDHE's April burning restrictions regulation, handouts, powerpoint	Y	Initial meetings & workshops would be educational & urge voluntary restrictions. Subsequent efforts would be focused on compliance with the new state regulation	Johnson Co.

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Activity	***Reason for activity and message to be conveyed***	***Target Audience(s)***	***Number of times activity will occur before next burn season***	***Could this activity be presented collaboratively with other organizations (Y or N)***	***Type of Materials Needed***	***Could this material be generated in a format for use by organizations other than your own? (Y or N)***	***Additional Clarification***	***Organization***
Distribute information	Education about benefits of Flint Hills burning & efforts to control smoke through SMP	General public, businesses already or potentially subject to Nox & VOC regulations, Chambers	Uncertain	Y	Brochure, handouts, powerpoint	Y	KDHE should develop these materials for distribution & common use in downwind areas	Johnson Co.
Track & submit data to KDHE	Track local burns (dates, location, acreage, reason for burning) to measure effectiveness of efforts to limit burning & determine if burns might have contributed to ozone exceedances	Local fire districts & departments, JO CO Environmental, city & county parks	Uncertain	Y	KDHE's April burning restrictions regulation, standardized data tracking sheet	Y		Johnson Co.
Distribute information	Education about economic & health impacts to downwind areas when Flint Hills burning takes place	Flint Hills property owners/managers	Uncertain	Y	Brochure	Y	KDHE needs to be involved in developing these materials	Johnson Co.

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Appendix **F** - Glossary

Agricultural burning——*See prescribed fire.*

Air quality (AQ)—The characteristics of the ambient air (all locations accessible to the general public) as indicated by concentrations of the six air pollutants for which national standards have been established [i.e., PM_{10}, $PM_{2.5}$, sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), and lead], and by visibility in mandatory Federal Class I areas.

Ambient Air—That portion of the atmosphere, external to buildings, to which the general public has access.

Attainment area—A geographic area in which levels of a criteria air pollutant meet the health-based primary standard (national ambient air quality standard, or NAAQS) for the pollutant. An area may have an acceptable level for one criteria air pollutant, but may have unacceptable levels for others. Thus, an area could be both attainment and non-attainment at the same time. Attainment areas are defined using pollutant limits set by the EPA.

Class I area—An area set aside under the Clean Air Act (CAA) to receive the most stringent protection from air quality degradation. Mandatory Class I Federal areas are (1) international parks, (2) national wilderness areas that exceed 5,000 acres in size, (3) national memorial parks that exceed 5,000 acres in size, and (4) national parks that exceed 6,000 acres and were in existence prior to the 1977 CAA Amendments. The extent of a mandatory Class I Federal area includes subsequent changes in boundaries, such as park expansions.

Clean Air Act Amendments (CAAA)—Federal laws added by the U.S. Congress to the original Clean Air Act of 1970. The last major change in the law, the Clean Air Act Amendments of 1990, was enacted by Congress in 1990. Legislation passed since then has made several minor changes.

Criteria air pollutants—A group of common air pollutants regulated by the EPA on the basis of criteria (information on health and/or environmental effects of pollution) and for which NAAQS have been established. In general, criteria air pollutants are widely distributed over the country. They are: PM_{10}, $PM_{2.5}$, carbon monoxide (CO), sulfur dioxide (SO_2), ozone (O_3), nitrogen oxides (NO_x), and lead.

Exceptional event—Exceptional events are events for which the normal planning and regulatory process established by the Clean Air Act (CAA) is not appropriate.

Federal Implementation Plan (FIP)—A plan (or portion thereof) promulgated by the Administrator, as provided for under the CAA and any applicable EPA regulations, including regulations governing tribal air plans, to fill all or a portion of a gap or

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otherwise correct all or a portion of an inadequacy in a state or tribal implementation plan (TIP), and which may include enforceable emission limitations or other control measures, means or techniques (including economic incentives, such as marketable permits or auctions of emissions allowances), and provides for attainment of the relevant national ambient air quality standard.

Federal land manager (FLM)—With respect to any lands in the United States, the Secretary of the federal department with authority over such lands. Generally, the Secretaries delegate their authority to specific elements within each department. For example, the National Park Service and the Fish and Wildlife Service manage those areas under the authority of the Department of the Interior.

Fire-dependent ecosystem—A community of plants and animals that must experience recurring disturbances by fire, in order to sustain its natural plant succession, structure and composition of vegetation, and maintain appropriate fuel loading and nutrient cycling to ensure proper ecosystem function.

Fire management plan (FMP)—A strategic plan that defines a program to manage wildland and prescribed fires, and documents the FMP to meet management objectives outlined in the approved land use plan. The plan is supplemented by operational procedures such as preparedness plans, burn plans, and prevention plans.

Flint Hills—A geographic region, running north and south through eastern Kansas and into northeast Oklahoma, dominated by a relatively unfragmented tallgrass prairie landscape of gently sloping limestone and chert hills. Roughly two-thirds of all the remaining tallgrass prairie in North America is contained in the Flint Hills.

Haze—An atmospheric aerosol of sufficient concentration to be visible. The particles are too small to see individually, but reduce visual range by scattering and absorbing light.

Intensive early stocking (IES)—A cattle management practice, common in the Flint Hills, whereby roughly twice the number of yearling cattle are stocked during the first half of the grazing season. IES practiced on pastures burned in the spring results in higher net financial returns compared to unburned pastures. Cattlemen recognized early on that burning Flint Hills pastures benefited cattle weight gains and the condition of their pastures.

Interagency Monitoring of Protected Visual Environments (IMPROVE)—A program that uses air monitors in Class I areas or outside Class I areas (IMPROVE protocol) to measure visibility pollutants including sulfates, nitrates, organic and elemental carbon, and PM_{10}.

Kansas Department of Health and Environment (KDHE)

DRAFT

Land use plan—A broad scale, long range plan (e.g., forest plan, refuge plan or resource management plan) that identifies the scope of actions and goals for the land and resources administered by a land owner/manager.

National Ambient Air Quality Standards (NAAQS) NAAQS)—Standards for maximum acceptable concentrations of "criteria" pollutants in the ambient air. Standards are established to protect public health with an adequate margin of safety (primary standard), and to protect public welfare (secondary standard) from any known or anticipated adverse effects of such pollutants (e.g., visibility impairment, soiling, materials damage, etc.) in the ambient air.

Nonattainment area—A geographic area in which the level of a criteria air pollutant is higher than the level allowed by the federal standards.

Nuisance smoke—Amounts of smoke in the ambient air that interfere with a right or privilege common to members of the public, including the use or enjoyment of public or private resources.

Ozone (O_3)—A gas consisting of three oxygen atoms. Ground-level ozone is a product of reactions among mainly nitrogen oxides and volatile organic compounds in the presence of sunlight. Ozone is the main component of smog.

Particulate matter (PM)— Any airborne finely divided material, except uncombined water, which exists as a solid or liquid at standard conditions (e.g., dust, smoke, mist, fumes, or smog).

Patch-burn grazing (PBG)—A pasture management practice used to enhance biological diversity and wildlife habitat on rangelands. Typically, one-third of a PBG pasture is burned each year on a rotational basis. When only a portion of a pasture is burned, livestock focus most of their grazing in the burned patches. The result is an accumulation of vegetation in unburned areas, creating wildlife habitat and fuels for fires in subsequent years.

PM_{10}—Particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers (including $PM_{2.5}$). Concentrations in the air are measured as micrograms per cubic meter of air ($\mu g/m^3$).

$PM_{2.5}$—Particles with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers. Concentrations in the air are measured as micrograms per cubic meter of air ($\mu g/m^3$).

Prescribed fire—Any fire ignited by management actions to meet specific objectives (i.e., managed to achieve resource benefits). As practiced in the Flint Hills, so-called range burning is a type of agriculturally based prescribed fire that is widely prescribed by range specialists and ecologists alike as a management tool necessary to maintain the ecological integrity of tallgrass prairie.

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Prescription—Measurable criteria that guide selection of appropriate management response and actions. Prescription criteria may include the meteorological conditions affecting the area under prescription, as well as factors related to the state of the area to be burned such as the fuel moisture condition and other physical parameters. Other criteria which may be considered include safety, economic, public health, environmental, geographic, administrative, social or legal considerations, and ecological and land use objectives.

Range burning—*See prescribed fire.*

Reid vapor pressure (RVP)—A common measure of the volatility of gasoline, defined as the absolute vapor pressure exerted by a liquid at 100 °F as determined by the test method ASTM-D-323.

Regional haze—Generally, concentrations of fine particles in the atmosphere from multiple sources extending hundreds of miles across a region and causing widespread visibility impairment, including mandatory Class I federal areas where visibility is an important value. The pollutants most responsible for haze include nitrates, sulfates, soil material, organic carbon, and elemental carbon. The last two are found in smoke from vegetative burning or are derived from components of smoke. Ozone also derives from fire emissions and can contribute to downwind haze.

Smoke management program or plan (SMP)—A document that establishes a basic framework of procedures and requirements for managing smoke from fires that are managed for resource benefits. The purposes of SMPs are to mitigate the nuisance and public safety hazards (e.g., on roadways and at airports) posed by smoke intrusions into populated areas; to prevent deterioration of air quality and NAAQS violations; and to address visibility impacts in mandatory Class I federal areas in accordance with the regional haze rules.

Source—Any place or object from which pollutants are released. A source can be a power plant, factory, dry cleaning business, gas station, or farm. Cars, trucks and other motor vehicles are sources, and consumer products and machines used in industry can also be sources. Sources that stay in one place are referred to as stationary sources; sources that move around, such as cars or planes, are called mobile sources.

State implementation plan (SIP)—A detailed description of the programs a state will use to carry out its responsibilities under the Clean Air Act. State implementation plans are collections of the regulations and emission reduction measures used by a state to reduce air pollution in order to attain and maintain NAAQS or to meet other requirements of the Act. The Clean Air Act requires that the EPA approve each state implementation plan. Members of the public are given opportunities to participate in review and approval of state implementation plans.

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Tallgrass prairie—One of the types of grassland that once dominated much of the interior of North America. Tallgrass prairie is characterized by higher rainfall than mid and shortgrass prairies to the west, and is represented by a few dominant, relatively deep-rooted warm-season grasses and numerous herbaceous perennial forbs.

Volatile organic compound (VOC)—Any organic compound that participates in atmospheric photochemical reactions, which are measured by a reference method, an equivalent method, or an alternative method. Some compounds are specifically listed as exempt due to their having negligible photochemical reactivity. Photochemical reactions of VOCs with oxides of nitrogen and sulfur can produce O_3 and PM in the presence of sunlight.

Wildfire—An unwanted wildland or agricultural fire.

Wildland—An area where development is generally limited to roads, railroads, power lines, and widely scattered structures. The land is not cultivated (i.e., the soil is disturbed less frequently than once in 10 years), is not fallow, and is not in the United States Department of Agriculture (USDA) Conservation Reserve Program. The land may be neglected altogether or managed for such purposes as wood or forage production, wildlife, recreation, wetlands, or protective plant cover. The distinction between wildlands and agricultural lands is not yet defined by EPA.

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Appendix G – Kansas National Weather Service Contact Information

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