3. Managing smoke: Our strategies and opportunities

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Pasture burning smoke management and air quality workshop
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Two strategies for reduction

Minimize smoke production
  – Not easy
  – Need more research

Reduce impact of smoke
  – Timing of burn
  – Communication
Minimize smoke production

- Frequency of burns
- Managing fuel load and fuel moistures
- Ignition and burn technique
Minimize smoke production

- **Frequency of burns**
  - Do I really need to burn this year to meet the objectives of land management?
  - Identify specific, quantifiable objectives of the prescribed fires in the Fire Management Practice Checklist
  - Consider non-burning alternative

- **Managing fuel load and fuel moistures**

- **Ignition and burn technique**
Minimize smoke production

- Frequency of burns
- Managing fuel load and fuel moistures
  - Vegetation management practices.
  - More frequent burning to reduce woody vegetation build-up
- Ignition and burn technique
Minimize smoke production

• Frequency of burns
• Managing fuel load and fuel moistures
• Ignition and burn technique
  – Backfires burn more efficiently than headfires, but headfires take less time to burn.
  – Reducing smoldering areas
Reduce impact of smoke

- Timing of burns
  - To allow for adequate smoke dispersion
  - To avoid current or forecasted poor air quality conditions
Reduce impact of smoke

How do weather conditions affect dispersion of smoke?

Vertical dispersion

High **mixing height** = gets smoke up, up, and away

Horizontal dispersion

Good **transport wind** = smoke goes away
Good wind direction = less smoke on sensitive spots
Mixing height defines the height above the ground through which the air is under turbulent mixing. It is the height at which smoke stops rising.

Adiabatic lapse rate (-9.8°C/km)

Stable

Unstable

Mixing height
Reduce impact of smoke

Mixing height (feet)

Ideal burning hours

Mixing height >1800 feet

Time
Reduce impact of smoke

Transport wind generally refers to the average rate of the horizontal transport of air within the mixing layer. Transport wind at 8-20 mph is desired for burning.

The average wind speed throughout the depth of the mixed layer
Reduce impact of smoke

**Recommended weather conditions for burning in the SMP**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Humidity: 30-55%</td>
<td>Reduced smoke production</td>
</tr>
<tr>
<td>Mixing height: &gt;1,800 feet (548m)</td>
<td>Adequate smoke dispersion</td>
</tr>
<tr>
<td>Transport winds: 8-20 mph (3.6-8.9 m/s)</td>
<td>Adequate smoke dispersion</td>
</tr>
<tr>
<td>Preferred start/stop times: 10 am to 6 pm</td>
<td>Reduced ozone production</td>
</tr>
<tr>
<td>Cloud cover: 30 to 50%</td>
<td>Reduced ozone production</td>
</tr>
</tbody>
</table>
Reduce impact of smoke

The National Weather Service (NWS) offer forecasts of **mixing height** and **transport winds** in their fire weather forecasts.

Topeka:

Wichita:
Reduce impact of smoke

Smoke screening

• Redistribute the emissions by burning when wind direction is favorable

• Use the smoke modeling tool provided on www.ksfire.org to understand
  – Where your individual plume will go?
  – Maximum contribution to major cities based on cumulative impact from fires that could be ignited within 48 hours
The modeling tool

For cumulative impact, use default burn characteristics and hypothetic fire locations.

For individual plumes, burn characteristics provided by users.

Weather forecast

HYSPLIT ready Meteorolog

BlueSky Framework Emission Model

HYSPLIT Dispersion run within BlueSky

Cumulative impact

Individual plume movement

Reduce impact of smoke
Two smoke models on www.ksfire.org

- **Model 1**: Estimate maximum contribution by county to major cities based on cumulative impact from fires that could be ignited within the next 48 hours
  - Use forecasted meteorology and expected emissions
  - County designated red, yellow or green based on country’s contribution to downwind air quality monitors.

- **Model 2**: Provide hourly individual plume movement and concentration to assess a burn
  - Users enter county, fire size, fuel load
  - Plume is brown, showing where the plume will go.

- Forecast discussion
Welcome to the Kansas Flint Hills Smoke Management Website. This site provides a single location for land managers conducting prescribed burns in the Flint Hills to obtain information and access tools to assist them in making burn decisions.

This website supports the Flint Hills Smoke Management Plan, which was developed in an attempt to balance the need for prescribed fire in the Flint Hills with the need for clean air in downwind communities.
Reduce impact of smoke

Model 1: cumulative impact
• A smoke green day is not necessary a safety green day.

• Unstable and windy conditions are excellent for smoke dispersal but burn with caution!
Reduce impact of smoke

Model 2: individual plume
Reduce impact of smoke

Avoid current or forecasted poor air quality conditions in downwind areas. Especially, avoid high O₃ day.

- Air quality condition - KDHE
  http://keap.kdhe.state.ks.us/airvision/
- Air quality forecast - NOAA
  http://airquality.weather.gov/
- Advisory comments on the smoke modeling tool on
  www.ksfire.org
Reduce impact of smoke

Other practices

• Test fire & evaluation
• Ration your smoke (less smoke density)
• Coordination of area burning to minimize cumulative smoke impacts
Reduce impact of smoke

Sometimes it is difficult to tell which way your smoke will go.
Coordination of area burning to minimize cumulative smoke impacts

• On a day with suitable weather conditions for burning, too many burns may occur at the same time. Preferably, burning can be planned cooperatively so as not to overwhelm the ability of the atmosphere to disperse the smoke.
Reduce impact of smoke

Summary of tools available to help you plan for, and communicate the impacts of smoke

- The smoke modeling tool on [www.ksfire.org](http://www.ksfire.org) for smoke screening
- Recommended weather conditions for burning in the SMP
- Fire weather forecasts provided by [www.weather.gov/forecasts](http://www.weather.gov/forecasts)
- Air quality information provided by KDHE and NOAA websites
- Data collection pilot program and the Fire Management Practice Checklist
- FIRMS web fire mapper at [https://firms.modaps.eosdis.nasa.gov/firemap/](https://firms.modaps.eosdis.nasa.gov/firemap/)
Two strategies for communication

**Notification**
- Sensitive populations
- Authorities

**Documentation**
- Record-keeping of BSMP’s, fire activity, and smoke behavior
- After-burn evaluation

Critical if seeking to be qualified as exceptional events

Data collection pilot program in the SMP
The SMP currently does not mandate notification and data collection. Currently each county has differing levels of reporting procedures and gathering of this information.

The goal of the data collection 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.
Documentation

Record-keeping of BSMP’s, fire activity, and smoke behavior

• Monitor the effects of the fire on air quality
  – Keeping track of where the smoke goes, how high it goes and whether it disperses well or is tight and dense, which can be done through visual monitoring and can be documented by notes, photographs

• If air quality problems occur, documentation helps analyze and address air regulatory issues

• If the state decides to seek to remove the data from the monitoring record, then documentation of BSMPs are critical.
A comprehensive burn plan

- Contact information
- Burn method and fuel type
- Smoke sensitive areas
- Acceptable smoke prescription
- Contingency planning
- Burn monitoring procedures
- Location and size of the burn
- Expected air emissions
- Smoke travel projections
- Description of alternatives to burning
- Public notification procedures
- Maps that show boundaries, ownership, control lines (& natural barriers) areas to be excluded
Documentation

After-burn evaluation

• Was preburn preparation properly done?
• Were objectives met?
• Was burn plan adhered to?
• Were all parameters (fuel, weather, smoke, fire behavior) within planned limits?
• Was burning technique correct?
• How can similar burns be improved?
Contingency measures

If the SMP is not effective enough to prevent an exceedance of the NAAQS, then certain contingency measures may need to be considered:

- Expand April burning restrictions to additional counties and applications.
- The scope and county coverage of smoke plans could be increased.
- Notification and data collection could become a requirement.
- Establish requirement for burn approvals based on meteorological and other conditions.
- Create a time of day window for burns.
- Open burning could be banned on certain days in which air quality could be severely impacted.
Smoke science and research needs

• Characterize emissions using different burn techniques and under different burn conditions
• Using remote sensing data to characterize fuel loading
• Monitoring of air quality during fire events
• Timing and frequency of burns
• Air quality implications of various management practices
• Health impact
• Burning effects on prairie chicken populations
Smoke research in KSU

• Source apportionment studies.
• Modeling analysis of history O$_3$ data in burn seasons.
• Assimilate satellites aerosol products such as aerosol optical depth (AOD) into the current emission processing model in order to improving emission estimation of prescribed burns.
Wish list of KDHE (from Thomas Gross)

• Add Lincoln, Omaha, other cities as potentially impacted areas to modeling tool, add extreme danger impact color code to model
• Conduct annual clipping study or satellite imagery analysis to determine fuel load
• Modeling analysis of history data in burn seasons to evaluate alternative control scenarios
• Study to determine baseline emissions profile of burning in the Flint Hills and changes with geography, time, and met conditions.
Long term strategies

• Smoke modeling
  – Improve and validate
  – Use real time fire data from remote sensing
  – Improve emission factors
  – A photochemical model that would provide a prediction of both $O_3$ and secondary organic aerosols from the burning
  – Future changes to air quality standards may require additional modeling tools.
Long term strategies

• Smoke measurement
  – Recent technology has made breakthroughs in measurement of organic compounds and has identified many new species in fire smoke.
  – Ground-based and aircraft aerosol measurements
  – Determine the optical density of the smoke by measuring the attenuation of a beam of light passing through the smoke
  – Investigate the evolution of secondary organic and black carbon aerosols
Extension and outreach strategies

Coordinate and create one authoritative information source, providing easy access to information.
Extension and outreach strategies

Identify target audiences and develop targeted messages, addressing specific information needs.

- Ranchers and land manager
- County emergency staff
- Urban audience
- Downwind communities
- General public
The key messages

General public, downwind communities

How will smoke affect me?

Why burning is Important?

How to reduce smoke impact?

Record and report smoke data to assist research and management

KDHE
K-State

Land manager, burn boss