Smoke Management for Prescribed Burning:
WHAT TO CONSIDER

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Managing smoke produced by prescribed fires has, in recent years, become a critical consideration when planning a prescribed fire event. In some situations, planning for smoke management may be more complicated than planning for the prescribed fire itself. Considerations such as human and animal health and safety, air pollution, and reduced visibilities must be taken into careful account when planning even a small, routine prescribed burn.

What we recognize as smoke is actually a cloud comprised of small – even microscopic – particulate matter (ash) carried into the air by heat produced from the combustion of fuels (plant or other material) in the fire. The smoke resulting from a particular fire is determined by the type of fuels being burned, how wet or cured those fuels might be, the type of fire (backing fire, headfire, etc.), time of year, and even weather conditions on a given day. All of these factors combine to influence relative size of the particulate matter, which in turn can produce smoke of different densities, colors, and problems posed to health and safety for people, animals, and the environment.

IOWA STATE UNIVERSITY
University Extension

PMR2088D September 2012

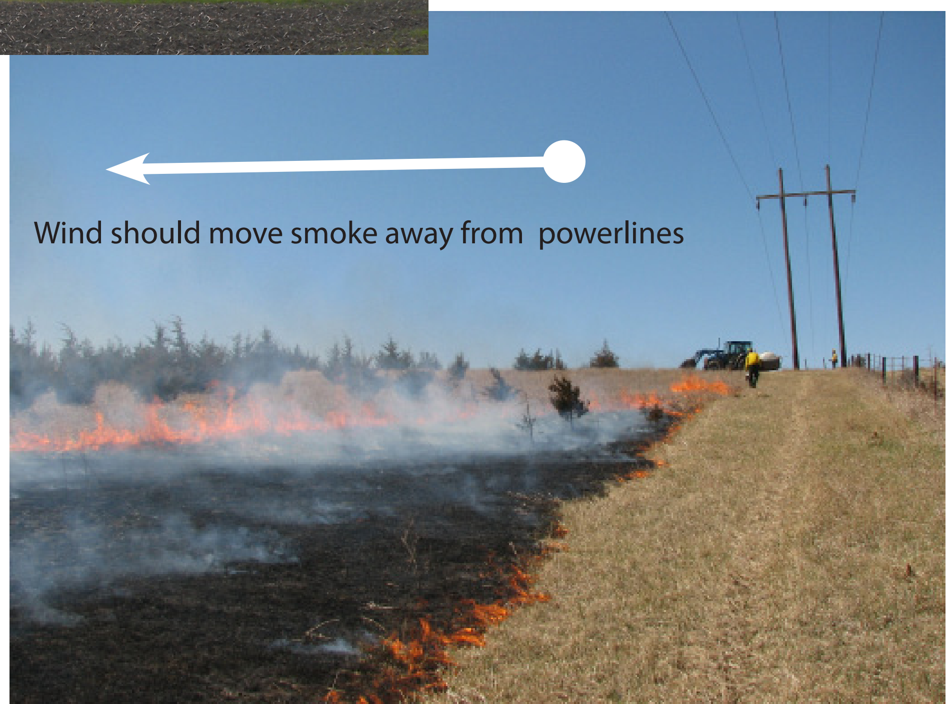
Smoke Sensitive Areas

One of the most important considerations when planning a prescribed fire is what features of the landscape surrounding a burn area will be impacted by smoke produced from a prescribed fire. Any houses, businesses, or roads are obvious examples of smoke sensitive areas, as smoke at any of these locations can pose health and safety problems for the people living, working, or traveling on them. Burning in or near cities or towns can be particularly complicated and problematic, because concentrations of people and traffic may make it difficult to find conditions that prevent or limit smoke impacts. Additionally, urban locations commonly have managed ventilation systems that could intake smoke. Larger urban areas are often designated as restricted airsheds, burning in these areas almost always requires a permit from federal, state, and local regulatory authorities.

Iowa's rural landscape contains many similar smoke sensitive areas encountered in more typically urban settings. Managed ventilation systems are commonplace on most modern livestock production facilities and can be impacted by smoke. Power and communication transmission lines can be negatively affected by smoke causing potential harm to both the lines and fire personnel. Dense particulate matter in the smoke can arc electricity between power transmission lines, potentially shorting them out and posing a risk of electrical shock to people or vehicles located below them.


Animal Confinement - Managed Ventilation System

Traffic control devices or personnel may be required when burning near roads


Wind should move smoke away from powerlines

Influence of Fuels and Ignition Patterns

The fuels (live & dead vegetation and litter) being burned and the technique, or type of fire, that is employed will directly determine the amount and density of smoke produced from a prescribed fire. Thus knowing what fuels exist in a burn unit and what type of fire techniques are needed can help plan for mitigating smoke issues.

Backing fires, or fires which are burning perpendicular to the prevailing wind direction or downslope (and thus moving relatively slower), tend to more completely consume fuels due to increased residence time and intensity of the fire on a given area. The smoke resulting from this more compete combustion tends to be thinner or less dense, owing to the finer size of the particulate matter produced. Smoke from a backing fire also tends to be lighter in color, again a result of the finer particulate size. This is contrasted against smoke produced from a headfire (a fire moving with the prevailing wind or upslope), which moves rapidly through the fuelbed. The rapid fire spread means less residence time and relatively less heat on a given area, and yields less complete combustion of the fuels. Smoke produced then tends to be darker, thicker or more dense, and can be more irritating to people; all owing to the larger relative size of the particulate matter produced. Flank fires, which are parallel to winds or slope, are both backing and heading fires, and so a mixture of smoke production can be expected.

Influence of Fuels and Ignition Patterns: Continued


Slow moving, patchy fire in SE Nebraska


Lighter, thinner smoke from a backing fire in Southern Iowa


Dry, heavy grass head fire in Southern Iowa


Dark, thick smoke produced by burning green invasive brush

Regardless of fuel type, the amount of greenness or relative moisture present in the fuels will increase the amount and density of smoke produced. This is a result of excess water vapor produced through consumption of the fuels. Smoke produced by burning fuels with a high amount of relative greenness or moisture can be much more irritating to personnel on the fireline, and to those areas that may be impacted by smoke near the fire. A prescribed fire conducted during the dormant season – when fuels are more cured and less moisture is present – will produce less smoke than a fire on the same site during the growing season, once green-up has begun.

Grass fuels tend to produce less smoke per unit area than do woodland or timber fuels, where downed logs, branches, shrubs and brush may be present in addition to leaf litter. Timber fuels may also harbor slightly more moisture due to the sheltering effect of the woodland canopy, making timing of a prescribed fire in these fuels even more important in terms of smoke management. Additionally, grass fuelbeds tend to be more open, allowing for more rapid smoke dispersion with wind and air currents, whereas the canopy or timber overstory tends to reduce air movements above the fuelbed, and thus smoke is more easily trapped and tends to linger in the area longer.

An important additional consideration when thinking about fuels and smoke management is whether or not noxious or irritating plants are present in the fuelbed. Smoke from burning plants such as poison ivy, for example, can cause problems for personnel on the fireline just as severe as if they had come into contact with the plant.

Weather Influence on Smoke

Weather can influence the smoke produced from a given fire as well as how it rises, mixes, and disperses in the atmosphere. Once the fuels to be burned have been identified, an understanding of weather conditions and their influence on smoke production and movement is vital.

Within the fuelbed of the burn unit itself, weather conditions such as relative humidity (RH) and temperature influence how fuels are consumed by the fire. As described above, the amount of moisture in the fuelbed can produce more or less smoke, and both temperature and relative humidity influence the moisture found in fine fuels (grasses and leaves) on a given day. Days with lower RH and warmer temperatures tend to produce relatively less smoke than do cooler, damper days. Several warm and dry days in a row will leave fuels much drier, and result in a fire with relatively less smoke on a burn day than would a burn conducted following several overcast, cool wet days. HOWEVER, it is important to remember that fire behavior itself may be more difficult to manage under these same warm, dry conditions.

Weather also plays a critical role in how smoke rises and disperses in the atmosphere. First and foremost, strong surface winds (those felt at ground level) on any day will keep smoke low to the ground, potentially impacting smoke sensitive areas farther away than on a day with lighter winds. Knowing the speed and direction of local winds is a critical consideration when planning any prescribed fire. As smoke rises above ground level, "winds aloft" or general winds become an important consideration, as they will move the smoke out and away from your burn area. Though often moving in the same direction as surface or local winds, this is not always the case, and so it is a good idea to check several online or other forecast resources to ensure that smoke won't move towards smoke sensitive towns, cities, or other areas.

In general, more atmospheric lift occurs under "unstable" air masses. These patterns are typically associated with areas of low pressure, and can be beneficial as smoke tends to rise and disperse more favorably. Unstable air masses tend to have the added benefit of sustained wind speeds and direction, which aides in planning for smoke management. Areas of higher atmospheric pressure are often described as "stable" air masses, and tend to have lighter winds with more variable directions, both of which can be problematic for effective smoke management. Stable air masses tend to have limited mixing of air currents, and so may trap smoke near the ground instead of allowing it to rise and disperse. These same effects can be seen at different times of the day: early in the day warm air may be trapped in a layer near ground level (inversion), and smoke produced may also remain trapped in this layer and cause lingering problems. Typically daily inversions break by midday, and a burn can be conducted later in the day that meets smoke management objectives.

Photo at Right: Smoke lingering in oak timber

More On Smoke Management

Planning for smoke management can be a seemingly daunting task when thinking about a prescribed fire; however, taking the time to think about what fuels are being burned, where the burn unit is located, and under what conditions a fire might be conducted can save a lot of headache later. A few simple ideas can be implemented to help in managing the smoke produced by a fire:

Fuels & Location:

- Know what fuels will be burned. Remember heavy fuels such as downed logs, branches, brush and shrubs produce more smoke than do fine fuels such as leaves and grass.
- Understand moisture and greenness patterns of local fuels, and burn at a time of year when greenness is at a minimum to reduce amount of smoke produced.
- Identify smoke sensitive areas prior to a prescribed burn, and avoid days when winds may push smoke onto or over these locations.
- Always notify local authorities (at a minimum, a county emergency dispatch center) and neighbors before conducting a prescribed burn. Local authorities may provide information on dangerous conditions, burn bans, or other concerns.
- When burning near complex smoke sensitive areas, visit with a person more experienced in prescribed fire management.

Burning Techniques:

- Consider using a backing fire in fuels where heavy smoke may be produced.
- Once solid black firelines are established, a strip fire on the inside of a backing fire may help pull smoke away from the fireline.
- A headfire will result in thicker smoke, but will burn more rapidly, thus shortening the time frame during which smoke is produced.
- For more experienced personnel, using techniques such as "ring" or "spot" ignition techniques inside the burn unit once solid black firelines are established can pull smoke away from firelines and create a more effective column to move smoke rapidly up into the atmosphere and away from ground level where it is more likely to impact smoke sensitive areas.

Weather Conditions:

- A warmer, drier day will produce relatively less smoke, and will typically have better lift than on cooler, more overcast days. However, it is important to remember that fire behavior may be more difficult to manage on such days.
- Identify which wind directions are favorable for moving smoke away from smoke sensitive areas, and plan for days with constant wind speed and directions.
- Avoid days of strong winds that will push smoke along the ground for long distances, potentially impacting smoke sensitive areas farther away.
- Days with unstable air masses tend to allow for better lift and dispersion of smoke into the atmosphere.
- Understand when (what seasons) stable air masses may cause inversions to occur and what time of day they are observed, and avoid burning under these conditions.

Prepared by: Jesse Randall, ISU Extension forester, and Ryan Harr, Assistant Scientist II, Natural Resources Ecology and Management. Related publications can be found on the ISU Extension Forestry web page at www.forestry.iastate.edu Search for publications PMR 2088A, Developing a Prescribed Fire Burn Plan, PMR 2088B, Tools and Safety Gear, PMR2088C, Why, When, and When Not to Burn, PMR 2088D, Smoke Management for Prescribed Burning, and PMR 2088E, Ignition Techniques. Materials listed are suggested safety items; many good substitutes are available. No product endorsement is implied by inclusion in this publication. Printed in cooperation with Iowa Dept. of Natural Resources Forestry Bureau and US Forest Service.

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Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Cathann Kress, Director, Cooperative Extension Service, Iowa State