Wisconsin

Smoke Management Best Management Practices for Prescribed Burns

Wisconsin Smoke Management Best Management Practices
Table of Contents

INTRODUCTION

Prescribed fire is an important tool in Wisconsin for restoring and maintaining fire dependent ecosystems, providing wildlife habitat, reducing hazardous fuel buildups, meeting silvicultural and other needs. However, wildland fire (wildfire and prescribed fire) can be a large, intermittent source of particulates that have the potential to cause significant short-term impacts on human health, welfare, safety, and visibility. This Smoke Management Best Management Practices (SMBMP) document has been developed to minimize those potential air quality impacts while optimizing the opportunity to use fire as a land management tool.

In 2005, several public and private land management agencies and organizations agreed to develop and implement SMBMP to mitigate potential air quality impacts from prescribed fire. In general, agencies and organizations in Wisconsin that conduct prescribed burns prepare site specific individual burn plans. State law and/or local ordinances may require burn permits for "open burning." Currently most prescribed fire plans include provisions that address the effects of smoke. These SMBMP will begin a formal effort to minimize impact of smoke produced from managed wildland fires in Wisconsin.

The signatories to this SMBMP document agree to abide by its provisions for prescribed fires they ignite for resource benefit. These SMBMP have been developed based on the principles identified in Section VI, "Smoke Management Programs" of the U.S. Environmental Protection Agency's (EPA) April 23, 1998 "Interim Air Quality Policy on Wildland and Prescribed Fires" (http://fire.r9.,fws.gov/ifcc/smoke/EPA_Policy.htm)

The Lands and Forestry Divisions and the Bureau of Air Management (Air and Waste Division) of the Wisconsin Department of Natural Resources (WDNR) serve as the central authority for the State's SMBMP. The SMBMP guidelines will become effective when the Department WDNR certifies in writing to Environmental Protection Administration (EPA) that a SMP has been adopted and implemented. The SMBMP document should be reviewed annually and amended as necessary to achieve the purpose of the SMBMP and incorporate changes in regulations, policies and advances in technology.

Organizations that May Wish to Sign-on to the SMBMP

In Wisconsin, The Nature Conservancy (TNC), WDNR, National Park Service (NPS), U.S. Fish & Wildlife Service (USFWS), U. S. Forest Service (USFS), Department of Defense (DOD), the Bureau of Indian Affairs (BIA), Menominee Indian Tribe of Wisconsin (MITW), Pheasants Forever, and several non-profit conservation groups all use fire to accomplish goals and objectives ranging from ecosystem management to fuels reduction. USDA conservation programs (i.e. Conservation Reserve Program, Wildlife Habitat Incentives Program) offered through the Farm Service Agency and Natural Resources Conservation Service (NRCS), place an emphasis on prescribed fire, making the increased use of prescribed fire in the private sector a general trend.

Signing organizations agree to follow the SMBMP guidelines in the next section as part of their burn plan.

Use of Fire as an Ecosystem Management Tool in Wisconsin

The use of prescribed fire presents the need to weigh the trade-offs associated with the ecological benefit of this practice vs. the impact of increased emissions from current and accelerated burning programs. Part of this trade-off involves the careful consideration of and application of smoke management techniques to minimize the impact of emissions, while still meeting ecological needs. An example of this trade-off to be considered is the increased fuel consumption from a wild fire

burning under severe meteorological conditions versus the reduced fuel consumption of a prescribed fire ignited that might burn under moderate weather conditions.

Many of the vegetative cover types within the state evolved with fire as the natural process for restoration and maintenance (Curtis). Prescribed fire, therefore, is the preferred management tool when safety and environmental conditions permit. Vegetative types ranging from grasslands and prairie plantings, to wetlands, savannas, conifer and hardwood forests, brush lands and agricultural fields are all treated with fire. Broadcast burning is the preferred method for landscape scale land treatments. Piled slash is burned throughout the year for cover type conversion, site preparation, and to mitigate insect and disease related problems, such as oak wilt.

Use of prescribed fire has been intermittent since the post-logging era wildland fires. The various ecosystem types that have a fire dependent element reflect the impacts of this intermittent pattern. Savannas, pine barrens, grasslands, and many other plant communities require fire for health and maintenance. The differing degree of fire occurrence over the past 100 years has contributed to the loss of acreage of these ecosystems.

In summary, the main reasons to use prescribed fire include:

- Wildlife habitat improvement and maintenance
- Site preparation and seed production
- Ecosystem management and restoration
- Maintenance of biological diversity
- Restoration of fire as a natural process
- Control of insect and disease
- Fuel reduction, including hazardous fuels
- Minimizing the potential for significant air quality impacts from wildfire
- The training of fire personnel resources
- Testing of fire suppression equipment and suppression techniques.

SMOKE MANAGEMENT BEST MANAGEMENT PRACTICES GUIDELINES

Purpose
These Smoke Management Best Management Practices (SMBMP) are a set of guidelines and procedures that are followed by signatory organizations to reduce the adverse effects of smoke from prescribed fires. The goal of the Wisconsin SMBMP is to prevent violations of the federal fine particles standard (PM2.5) and minimize adverse effects including:

- Health effects from smoke inhalation
    - Premature death
    - Decreased lung function
    - Increased asthma attacks and chronic bronchitis
    - Acute respiratory symptoms
    - Respiratory and cardiopulmonary related hospital admissions
    - Increased work and school absences
- Visibility related travel hazards
    - Aircraft
    - Highways
    - Rail
- Electric utility hazards
- Violations of an ambient air quality standard
- Decreased visibility in scenic vistas

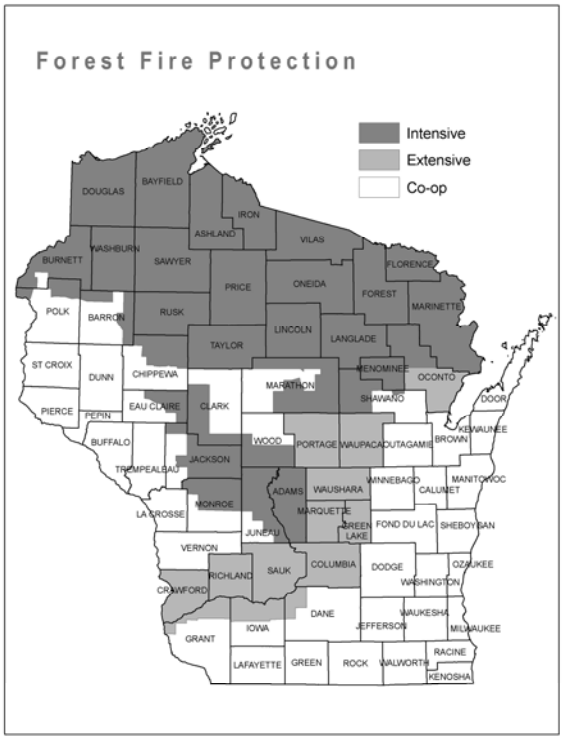
Authorization to Burn
The WDNR Division of Forestry is responsible for issuing permits for open burning in organized protection areas, outside of incorporated cities or villages, of Wisconsin (Figure 1), for forest fire protection purposes. In cooperative protection areas, town chairpersons are responsible for issuing permits for open burning for forest fire protection purposes. This authority is stated in Wisconsin State Statute Chapter 26 and associated administrative rules.

The WDNR issues written permits for open burning of vegetative materials. A permit is not required when the ground is covered with snow. Permitting of open burning is also administered locally when municipalities or townships have local ordinances more restrictive than the state rules.

Wisconsin Administrative Code, NR 429.04(1), prohibits open burning with certain exceptions. One of those exceptions is backfires to control forest fires or fires set for forest or wildlife habitat management with the approval of the department where no reasonable alternative is available. Factors in considering the reasonableness of alternatives may include: 1) costs of other alternatives, 2) availability of other alternatives; or 3) effectiveness of each of the other alternatives in comparison to a prescribed burn in achieving the land management objectives. In addition, NR 429.04(2) specifies that all allowed open burning shall be conducted in a safe pollution-free manner, when wind and weather conditions will minimize adverse effects and in conformance with local and state fire protection regulations.

Prescribed burning on public lands in Wisconsin is done under the on-site supervision of an agency certified burn boss.

Figure 1



Historically the Federal agencies in Wisconsin have complied with state burning regulations. Procedures for coordinating open burning restrictions between state and federal agencies have been handled by the Wisconsin Interagency Fire Council. These SMBMP are a formal agreement among signatory agencies for state burning regulation compliance for the purposes of future smoke related emission and impact reduction.

In the event that an air quality watch or advisory is declared by WDNR, signatories to this SMBMP agree to cancel all open burning related to prescribed fire use for the applicable county or counties affected by the burn while the advisory remains in effect. The WDNR has a website at http://dnr.wi.gov/air/aq/health/status.asp for air quality watches and advisories.

Burn Plans

All signatories to this SMBMP agree to have burn plans that incorporate the elements listed below. They should be on file at agency or organization offices and are available upon request. These prescribed burn plans will include the following elements at a minimum:

- Location and legal description (Town, Range, Section and quarter-quarter section) of the area to be treated, including ownership.
- Personnel and/or certified prescribed burn boss responsible for managing the fire.
- Type of vegetation or fuel model (utilizing the National Fire Behavior Prediction System) to be burned.
- Area in acres to be burned.
- Amount of fuel to be consumed*
- Fire prescription including smoke management components and ventilation index limits.
- Criteria the fire manager will use for making go-no-go burn decisions.

- Safety and contingency plans.

**As an example, if burning in a fuel model 6 (brush fuel type), and the objective is to top kill 75% of the woody vegetation ,this can be calculated by multiplying average fuel present (6 tons/acre) by 75%. This results in amount of fuel to be consumed equaling 4-1/2 tons/acre.*

Smoke Management Best Management Practices for Burn Plans

Actions to Minimize Fire Emissions – The burn plan should document the steps to be taken prior to, during, and after the burn to reduce air emissions. This could include, but may not be limited to, any of the following measures (NWCG Smoke Management Guide for Prescribed and Wildland Fires, 2001):

- Minimize the area burned; reduce the acreage burned per burning period, or use non-fire treatments.
- Reduce the fuel loading in the area to be burned by mechanical means, or by using frequent, low intensity burns to gradually reduce fuels.
- Reduce the amount of fuel consumed by the fire by burning when large non-target fuel moistures and duff moistures are higher.
- Minimize emissions per ton of fuel consumed, by using mass ignition techniques, using backing fires, increasing combustion efficiency and performing rapid and complete mop-up.
- Pre-treat heavy fuels or use firing techniques that exclude them from the burn.
- Minimize potential smoke impacts on sensitive receptors

Evaluate Smoke Dispersion and Sensitive Receptor Sites

Prescribed burn plans should identify and evaluate potential smoke impacts on sensitive receptors. Fires should be timed to minimize exposure of sensitive populations (those that smoke may present particular health risks).

There are 5 steps to address sensitive receptor sites and smoke dispersion:
1. Identify and list sensitive receptor sites
2. Specify the requirements for smoke dispersal at sensitive receptor sites
3. Check for Air Quality Watches or Advisories
4. Notify affected populations and authorities
5. Identify monitoring plans for sensitive receptor sites

These steps are further described below.

1. Identify and list sensitive receptor sites

Sensitive receptor sites are usually defined as locations where human populations tend to concentrate and where smoke could impact the health of those populations or significantly impact visibility that may be detrimental to health or the enjoyment of scenic qualities of the landscape. These may be residential concentrations in the form of towns or cities, or locations where people tend to gather in groups such as parks and schools. Travel routes such as highways may be labeled as sensitive receptor sites where smoke can be a factor in potential motor vehicle accidents. Particular areas along highways or other locations may be more prone to being declared sensitive receptor sites because of topographic and microclimate features.

2. Specify the requirements for smoke dispersal at sensitive receptor sites

The plan should identify the distance and direction from the burn site to local sensitive receptor areas where appropriate. Fire prescriptions will specify minimum requirements for the atmospheric capacity for smoke dispersal such as minimum surface and upper level wind speeds, desired wind direction, minimum mixing height, and dispersion index. Utilize the Ventilation Index explained in Appendix D for minimum requirements.

Another source of information for burn day decisions in counties with an air quality monitor is the Air Quality Index (AQI). Check the AQI for the area of the burn and downwind impact zone on the WDNR internet website, at http://dnrmaps.wi.gov/wisards . Values at or above the AQI orange (unhealthy for sensitive groups) or red (unhealthy) categories for the burn and the downwind impact zone should be considered in the decision making process.

3. Check for Air Quality Watches or Advisories
The burn boss or prescribed fire manager responsible for a proposed prescribed burn has the responsibility to assure that there is no air quality advisory or watch in effect for the county or counties affected by smoke dispersal on the day that the prescribed burn occurs. Check the WDNR website at http://dnr.wi.gov/air/aq/health/status.asp or the National Weather Service website at http://www.crh.noaa.gov/mkx/ which posts air quality watches and advisories.

4. Notify affected populations and authorities
The burn plan should identify actions that will be taken to notify populations and authorities at sensitive receptors, including those in adjacent jurisdictions, prior to the fire. The plan should also identify contingency recommendations that should be taken during a fire to reduce the exposure of people at sensitive receptors if smoke intrusions occur. These recommendations are from the National Wildfire Coordinating Group's Smoke Management Techniques Course (Rx-410) and include the following:

- Notify sensitive receptors and DNR Air Management as soon as possible when conditions change.
- Place field observers at sensitive receptors to monitor smoke conditions.
- Work with local health agencies and DNR Air Management (issues air quality health advisories).
- Relocate smoke-sensitive people.
- Terminate project.
- Accelerate completion of project.

5. Identify monitoring plans for sensitive receptor sites
The plan should identify how the effects of the fire on air quality at sensitive receptors areas should be monitored. The extent of the monitoring plan should match the size of the fire, fuel loading and consider the proximity to smoke sensitive areas. For small, or short duration fires (such as those in grass or leaf litter), visual monitoring of the directions of the smoke plume and monitoring nuisance complaints by the public may be sufficient. Other monitoring techniques include posting personnel at sensitive receptors to look for smoke intrusions and continued tracking of meteorological conditions during the fire. For fires in fuels with longer duration burning (such as timber litter or slash), and which are expected to last more than one day, locating real-time PM monitors at sensitive receptors may be warranted to facilitate timely response to smoke impacts.

Smoke Management Best Management Practices Related to Road Impacts
The Wisconsin Department of Transportation (WDOT) is responsible for maintaining the state and federal highways within Wisconsin. WDOT has 8 Region offices to serve the transportation needs of Wisconsin motorists, location and right-of-way contacts are available on the following web site www.dot.wisconsin.gov/business/rules/docs/contact-row.pdf.

Planning for smoke management adjacent to state and federal highways begins with contacting the local WDOT Regional Office to determine if a DOT permit is required. If a prescribed burn is being planned within WDOT right-of-way (ROW) by another state or federal land management agency, organization or private landowner, and a DOT permit is required, the following documents will be submitted to the WDOT Regional Right of Way permit contact:

1. *Application/Permit To Work on Highway Right-Of-Way* (WDOT Form DT 1812)
2. The Burn Plan

*WDOT forms are available from the local Regional office and online www.dot.wisconsin.gov/forms/docs/dt1812.doc.

Processing time for permit approval is up to 30 days and is intended for non-emergency activities. The approval of an annual permit rather than an individual permit may be desirable to accommodate flexibility in the time range to complete multiple burns adjacent to highways planned by state and federal land managers.

The thresholds for pre-planning the distance of a burn from travel routes should be determined on a site-by-site basis. Property ownership, rural vs. urban environment, average daily traffic (ADT) and the justification for burning within the vegetated ROW should be evaluated and addressed within the burn plan.

Participation in the WDOT ROW permit process as described above should assure that the Burn Boss/Fire Manager should receive specific information on the required signage and its proper placement within the ROW. The WDOT brochure *Work Zone Safety: Guidelines for Construction, Maintenance, & Utility Operations* is an excellent reference and is available on line at www.dot.wisconsin.gov/business/rules/docs/wzsb.pdf . The use of electronically programmable signs for smoke warning and speed reduction is an option. The responsibility for providing standard signs or renting the programmable signs lies with the agency or organization conducting the prescribed burn. Traffic control devices placed and maintained by the State, County, City or other local officials are required by Wisconsin Law to conform to the *Wisconsin Manual on Uniform Traffic Control Devices*. The manual can be downloaded from www.dot.wisconsin.gov/business/engrserv/ .

For emergency situations fire officials should immediately call 911 or local law enforcement or contact the local Region WDOT Emergency Coordinator for the fastest response. The use of signage, the decision to temporarily close a state or federal highway and to reroute traffic must be coordinated with WDOT in cooperation with fire officials and law enforcement.

Responsibility for county, city, or town roads is under the jurisdiction of the local unit of government. Fire managers/burn bosses need to contact local highway officials for the permitting process. Please refer to the following website for contact information for each County Highway Commissioner in Wisconsin www.wcha.net/CO/Co_Map_Page.htm .

Authority to control traffic must be coordinated with state, county, or local units of government having jurisdiction over the road. **The best practice would be not to burn when it is apparent that smoke would be placed over a roadway.**

For detailed information about all roads within the state of Wisconsin including State and Federal Routes, County roads, Town roads or others, please visit the following website: www.dot.wisconsin.gov/travel/maps .

Smoke Management Best Management Practices Related to Railway Impacts
Contact the emergency management representative for the specific railroad effected. These representatives should have firsthand knowledge of their internal processes for emergency response to smoke and the timing of rail activity along the rail line.

The *Official Rail Map* and directory of railroads is available from the WDOT public website: www.dot.wisconsin.gov/travel/rail . The *Wisconsin Rail Map*, *Emergency Railroad Phone Numbers* and *Required Clearances near Railroad Tracks* are just a few of the documents available to assist in planning for smoke management along railroad corridors.

Smoke Management Best Management Practices Related to Air Traffic Impacts
The coordinating agency should contact any private and/or public airport within 10 miles of the closest burn perimeter so that air traffic control is aware of the situation. Prescribed burning within 5 miles of an airport perimeter should be closely coordinated with the airport manager/owner so that the burn does not conflict with airport usage (e.g. new pilot training). Airport locations can be obtained using www.dot.wisconsin.gov/travel/air . This link can provide detailed information on locations and contact information.

Smoke Management Best Management Practices Related to Utility Impacts
The safety of fire line personnel in relation to fire use near overhead transmission lines, where smoke, ash and incidental mist from fire line operations may contaminate the insulators on transmission structures is a consideration. Standard utility recommendations are to maintain a minimum radial distance of 35 feet between firefighters, vehicles and transmission structures to protect fire fighting personnel from this electrical hazard. Further recommendations would be to place containment lines no closer than 100 feet of and parallel to the edge of the outer most conductor.

Planning to address the direction and dispersion of smoke in these situations is critical as a heavy smoke plume on power lines may cause a conductor to ground short. Consider including any utility owner or operator that maybe impacted in the planning process. Qualified company representatives are responsible for safely adhering to all other rules pertaining to this subject matter.

Smoke Management Best Management Practices and Dispersion
The National Weather Service (NWS) forecast offices in Green Bay, Sullivan, LaCrosse, Duluth, MN, and Minneapolis, MN provide twice daily fire weather forecasts every day during the fire season (generally April 1 to November 1). The fire weather forecasts issued by the respective NWS offices, at 0700 and again by 1500, include projected smoke management information. The Fire Weather Annual Operating Plan (FWAOP) available at the forecast offices or most agency dispatch or coordination centers provides extensive forecast information. State and Federal Agency Prescribed fire managers who plan ignitions at other than the forecast time may request dispersion/ventilation criteria as part of a spot weather forecast from the NWS. At this time a spot weather forecast from the NWS is not available to the private sector.

To ensure optimum dispersal of smoke emissions during prescribed burns, the mixing height should be deep enough and have sufficient transport wind speed to ensure the dilution and dispersal of emission concentrations. The ventilation index multiplies mixing height (measured in feet) and transport wind speed (measured in knots per hour) to produce an index that expresses the ability of the atmosphere to disperse emissions. This dispersion information is included as part of the daily fire weather forecast. It describes the mixing height, transport wind speed and ventilation index for the peak or low conditions during the forecast period. For more information on the ventilation index refer to Appendix D.

Public Education and Awareness
Agencies and organizations should work to establish and maintain programs to stress the use and importance of fire for ecosystem and related land management goals. Public health and safety are critical to this effort. The Wisconsin Prescribed Fire Council has been working towards this goal since 2002.

Surveillance and Enforcement:

Failing to follow the burn plan prescription, agency and TNC certified burn bosses would be subject to that organization's specific review protocols and possible disciplinary action. Formal after-action reports generated by any agency review should be forwarded to that agency's representative to the Wisconsin Interagency Fire Council (WIFC). The agency representative will then forward the review on to the remaining members of WIFC, to promote lessons learned. Agencies are encouraged to include private sector members from the Wisconsin Prescribed Fire Council Board of Directors in any after-action review. Agency-certified prescribed burn bosses follow a pre-burn go-no-go procedure to ensure that the burn day parameters meet the burn plan prescription including SMBMP.

Private sector agencies, who are signatories on this SMBMP, who do not follow the burn plan prescription would be subject to the following peer review protocol. Smoke intrusions and/or escaped prescribed burn are two examples that could trigger a review. A three person review team will be organized consisting of: 1) representative chosen by the private burn boss, 2) WDNR representative, and 3) representative from the WIFC agreed to by both WDNR and the private burn manager/boss. The group would review the burn proposal, weather conditions, go-no-go decision process, and other factors regarding the prescribed burn. The review team would make recommendations to the WDNR and WIFC as to appropriate corrective actions. These actions could include (but are not limited to): no action (plan was good and followed), removal as a signatory to the SMBMP document, prescribed burn plans requiring a peer review before being implemented, or denied future approval under NR429. WDNR, as the central authority, in consultation with WIFC would make the finial determination on recommended actions. Should legal action be taken for a prescribed burn that may trigger a review, the review may be delayed or pre-empted by necessary legal considerations.

Private sector burn managers/burn bosses are encouraged to summit one burn plan per year to the WDNR Fire Operations Specialist (1500 N. Johns Street, Dodgeville, WI 53533) for a peer review. Private sector burn bosses are encouraged to utilize Wisconsin Prescribed Fire Council's go-no-go checklist to ensure that the burn day parameters meet the burn plan prescription, including smoke management concerns.

Optional Air Quality Protection

Agencies should consider opportunities to establish specific, stringent protection for those special areas requiring additional regulation in the interest of public health and safety. Recognition of these areas should be documented in site-specific burn unit plans, along with the steps to minimize impacts.

Program Evaluation

To evaluate the effectiveness of the SMBMP, an interagency prescribed fire stakeholder group should annually review information on acres burned by fuel type with prescribed fire. Reports of nuisance complaints or smoke intrusions should be noted and the interagency prescribed fire stakeholder group should use this information to measure the effectiveness of this plan. The WDNR recommends that SMBMP member agencies maintain records necessary to demonstrate an Exceptional Event, per Environmental Protection Agency 40 CFR Parts 50 and 51, Treatment of Data Influenced by Exceptional Events; Final Rule, for the necessary time that the WDNR is required to report data to the EPA. In 2009, the duration was 4 years.

In addition, the WDNR should review data from the existing $PM_{2.5}$, and ozone monitors in Wisconsin. Correlations of air quality (NAAQS) with prescribed fire should be assessed for the interagency prescribed fire stakeholder group. In the event an exceedance (PM_{10}, $PM_{2.5}$, or ozone) is recorded, WDNR will notify the principal contacts listed in the Memorandum of Agreement between the

signatories of these SMBMP to ensure the documentation necessary to demonstrate an Exceptional Event is collated and available.

The interagency prescribed fire stakeholder group should also review annually:

- The acres of prescribed burns by fuel type and any associated air quality issues,
- The need for changes in the SMBMP.

This SMBMP document is an evolving and will undergo ongoing evaluation using stakeholder input.

Upon implementation of this plan, signatories should annually submit electronically on WDNR forms by January 31 of each year to the Forest Protection Section – Operations Specialist the following:

- Acres prescribed burned by fuel type for the previous calendar year.
- Date of burns.
- Duration of burns.
- Moisture content (if available)
- Location and legal description of burns conducted.
- Nuisance complaints or smoke intrusions.

WDNR will estimate emissions based upon stakeholder inputs for inclusion in the annual emissions report for the previous calendar year to EPA.

GLOSSARY

Air Quality -- 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., particulate matter (PM), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO) and lead], and by measurement of visibility in mandatory Federal Class I areas.

Air Quality Advisory -- An air quality advisory is issued when the ambient air quality in an area is unhealthy for sensitive individuals or when the air quality is expected to degrade to that level within a few hours.

Air Quality Watch – An air quality watch is called for an area when the air quality forecasts for the next day, or the next few days, indicates that there is a potential for air quality to become unhealthy for sensitive individuals.

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 national ambient air quality standard, or NAAQS for the pollutant. An area may have on 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 federal pollutant limits set by EPA.

Burn Boss -- Person responsible for supervising a prescribed burn from ignition through mop-up.

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 which exceed 5,000 acres in size, (3) national memorial parks which exceed 5,000 acres in size, and (4) national parks which 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.

Combustion -- Burning. Many important pollutants, such as sulfur dioxide, nitrogen oxides, and particulates (PM_{10}) are combustion products, often products of the burning of fuels such as coal, oil, gas and wood

Criteria air pollutants -- A group of very common air pollutants regulated by 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 all over the country. They are: particulate matter (PM), carbon monoxide (CO), sulfur dioxide (SO_2), ozone (0_3), Nitrogen Oxide (NOx) and lead (Pb).

Emission -- Release of pollutants into the air from a mobile source (e.g. vehicle), stationary source (e.g. industry), or area sources (e.g. gas stations, chimneys, vegetative burning). We say sources emit pollutants

Fuel -- Includes combustible vegetative matter such as grass, trees, shrubs, limbs, branches, duff, and stumps.

Haze -- Particles in the air that scatter light and degrade visibility.

Monitoring (monitor) -- Measurement of air pollution is referred to as monitoring. EPA, state and local agencies measure the types and amounts of pollutants in the ambient in community air.

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

Non-attainment area -- A geographic area in which the level of a criteria air pollutant is higher than the level allowed by the federal standards. A single geographic area may have levels that are acceptable of one criteria air pollutant but unacceptable levels of one or more other criteria air pollutants; thus, an area can be both attainment and non-attainment at the same time.

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 -- A highly reactive gas consisting of three oxygen atoms.

Particulate Matter (PM) --Any airborne finely divided material mixture of very small particles that are suspended in the atmosphere, except uncombined water, which exists as a solid or liquid at standard conditions (e.g., dust, smoke, mist, fumes, or smog).

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 ($\mu g/m^3$).

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.

Prevention of Significant Deterioration (PSD) -- A requirement in the Clean Air Act, which establishes the maximum allowable increases in ambient air concentrations of selected air pollutants above baseline concentrations in areas designated as Class I, Class II, or Class III.

Prescribed Fire -- Any fire ignited by management actions to meet specific objectives. For federal agencies a written, approved prescribed fire plan must exist, and NEPA requirements (where applicable) must be met, prior to ignition.

Sensitive populations -- Those populations to which smoke emissions may present particular health risks.

Sensitive Receptors -- Locations where human population tend to concentrate and where smoke could impact the health of those population or significantly impact visibility that may be detrimental to either health or the enjoyment of scenic qualities of the landscape. These may be residential concentrations in the form of towns or cities, or locations where people tend gather in groups such as parks. Travel routes such as highways may be labeled as sensitive receptor sites where smoke can be a factor in potential motor vehicle accidents. Particular areas along highways or other locations may be more prone to being declared sensitive receptor sites because of topographic and microclimate features. *(i.e.--Population centers such as towns and villages, camp grounds and trails, hospitals, nursing homes, schools, roads, airports, mandatory Class I Federal areas, etc. where smoke and air pollutants can adversely affect public health, safety and welfare.)*

Smoke Management Best Management Practices (SMBMP) -- Establishes a basic framework of procedures and requirements for managing smoke from fires that are managed for resource benefits. The purposes of SMBMPs are to mitigate the health, 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, such as power plants, factories, dry cleaners, gas stations, farms, motor and consumer products.

State Implementation Plan (SIP) -- 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 EPA approve each state implementation plan.

Violation of the PM NAAQS -- As revised in 2006, the daily PM_{10} standard is violated when the 99th percentile of the distribution of 24-hour concentrations for a period of 1 year (averaged over 3 calendar years) exceeds 150 $\mu g/m^3$ at any monitor within an area. $PM_{2.5}$ are set at a daily concentration less than or equal to 35 $\mu g/m^3$, and an annual mean

concentration of less than or equal to 15 μg/$m^{3.}$ For $PM_{2.5}$ the daily standard is violated when the 98th percentile of the distribution of the
24-hour concentrations for a period of 1 year (averaged over 3 calendar years) exceed 35 μg/m^3 at any monitor within an area. The annual standard is violated when the annual arithmetic mean of the 24-hour concentrations from a network of one or more population-oriented monitors (averaged over 3 calendar years) exceeds 15 μg/m^3.

Wildfire -- An unplanned and unwanted wildland fire including unauthorized human-caused fire, escaped prescribed fire projects, and all other wildland fires where the objective is to put the fire out.

Wildland Fire -- Any non-structural fire that occurs in the wildland. Two distinct types of wildland fire have been defined in Wisconsin and include wildfire and prescribed fire.

Wisconsin Interagency Fire Council – The Wisconsin Interagency Fire Council consists of representatives of the Wisconsin Department of Natural Resources, US Fish & Wildlife Service, US Forest Service, Menominee Tribal Enterprises, Bureau of Indian Affairs and National Park Service. For the purposes of the Smoke Management Best Management Practices, WIFC would also include representatives of the other signatories to the SMBMP including, but not limited to, The Nature Conservancy and the Wisconsin Prescribed Fire Council.

LITERATURE CITED

Anderson, G.K., Sandberg, D.V., Norheim, R. 2004. Fire Emissions Production Simulator (FEPS) User's Guide ver. 1. USDA Pacific Northwest Research Station, Fire and Environmental Research Applications team. Seattle, WA

Anderson, H.E. 1982. Aids in Determining Fuel Models for Estimating Fire Behavior. Gen. Tech. Rep. INT-122. Fort Collins, CO.

Curtis, J.T. 1959. The Vegetation of Wisconsin: An Ordination of Plant Communities. Univ. of Wisconsin Printing. Madison, WI

Dorney, J. R. 1981. The Impact of Native Americans on Pre-settlement Vegetation in Southeastern Wisconsin. Wisconsin Academy of Sciences, Vol. 69: 26-36.

Dorney, C.H., Dorney, J.R. 1989. An Unusual Oak Savanna in Northeastern Wisconsin: The Effect of Indian-Caused Fire. American Midland Naturalist, Vol. 122, #1: 103-113.

EPA. 1992. Prescribed burning background document and technical information document for prescribed burning best available control measures. Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711. EPA-45012-92-003.

EPA. 1998. Interim air quality policy on wildland and prescribed fires. Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

Michigan DNR. 2006. Michigan Smoke Management Program.

MN ICS. 2007. Minnesota Smoke Management Plan.

National Wildfire Coordination Group. 2001. Smoke Management Guide for Prescribed and Wildland Fire. PMS 420-2. Boise, ID.

National Wildfire Coordination Group. 2003. Smoke Management Techniques Instructor Guide, Course RX-410. NFES 2475, Boise, ID

Ottmar, R. D., and R. E. Vihnanek. 1999. Stereo photo series for quantifying natural fuels. Volume V: Midwest Red and White Pine, Northern Tallgrass Prairie, and Mixed Oak Types in the Central and Lake States. PMS 834. Boise, ID.

Peterson, J., and B. Leenhouts. 1997. What wildland fire conditions minimize emissions and hazardous air pollutants and can land management goals still be met? (Unpublished support document to the EPA Interim Air Quality Policy on Wildland and Prescribed Fires. August 15, 1997.)

Sandberg, D.V., Ottmar, R.D., Peterson, J.L., and Core, J. 2002. Wildland fire on ecosystems: effects of fire on air. Gen. Tech. Rep. RMRS-GTR-42-vol. 5. Ogen, UT.

Scott, J.H., Burgan, R.E. 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface spread model. Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO.

Williams, G.W. 2000. Introduction to Aboriginal Fire Use in North America. Fire Mgmt Today 60(Summer): 8-12.

Table 1

Interagency Prescribed Burns Completed									
Agency	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total Acres 2002-2009**
USF&WS	5677	6928	5996	9345	7681	9601	7982	7359	60569
WDNR	18750	19750	19500	20000	19000	27000	21550	21330	166880
USFS	586	2108	1259	1045	3211	1201	3450	775	13635
TNC	818	636	609	418	895	596	375	550	4897
Pheasants Forever	100	150	295	200	850	870	500	775	13635
NRCS		40	30	350	830	1015	3826	7010	13101
DoD Fort McCoy	5121	5583	5627	5270	5731	4856	3130	550	4897
BIA			400	630	720	100	350	1258	3458
WDOT		160	280	80	120	80	20	30	770
Mississippi Valley Consevancy					129	56	22	60	267
MITW		140	11	371	280	521	514	850	2936
Total Acres	31052	35335	33727	37629	39198	45760	41677	48157	319087

NOTE: The prescribed burn acres in Table 1 are the best data available; some burn acreage may have been missed or double reported.

APPENDICES

Appendix A
Federal and State Laws Related to Smoke Management Best Management Practices

Legal Requirements and Environmental Regulations for Wisconsin Smoke Management Best Management Practices

The Clean Air Act (Public Law 95-95) as amended in 1977 and 1990 identifies standards and legal requirements that must be met by the EPA, other Federal agencies, the states, and industry. Prior to 1990, the Federal Clean Air Act did not directly address prescribed burning. However, the latest amendments contain a number of sections which may result in both direct and indirect regulatory controls.

Section 109 of the Clean Air Act (CAA) requires EPA to develop primary ambient air quality standards to protect human health and secondary standards to protect welfare. In July of 1987, the EPA promulgated ambient air quality standards for those particulates less than 10 microns in diameter (PM_{10}). The PM_{10} standards were designed to protect that portion of the population which is most susceptible to the effects of airborne respirable particles with an adequate margin of safety. However, more recent research indicated that the PM_{10} standard did not protect those people who already had existing respiratory problems. As a result EPA issued their initial fine particulate standards in July, 1997 to regulate those particulates less than 2.5 microns in diameter ($PM_{2.5}$). These standards are of interest to the fire community because approximately 70% of the particulate emitted from biomass burning are in this size range. More current epidemiological studies indicate a much stronger relationship between increases in $PM_{2.5}$ concentrations and mortality and morbidity. As a result, EPA revised these standards in September, 2006 reducing the 24 hr standard from 65 to 35 micrograms per cubic meter ($\mu g/m^{3)}$. The annual standard stayed the same at 15 ($\mu g/m^3$). (Table B1, PM Ambient Air Quality Standards)

Table A1 (From MI SMP 2007)

EPA's PM Standards: Old and New

	1997 Standards July 17, 1997		2006 Standards September 21, 2006	
	Annual	**24-hour**	**Annual**	**24-hour**
$PM_{2.5}$ (Fine Particles)	**15 $\mu g/m^3$** Annual average	**65 $\mu g/m^3$** 98th percentile	**15 $\mu g/m^3$** Annual average	**35 $\mu g/m^3$** 98th percentile
PM_{10} (Coarse Particles)	**50 $\mu g/m^3$** Annual average	**150 $\mu g/m^3$** 1 expected exceedance	**Revoked**	**150 $\mu g/m^3$** 1 expected exceedance

Wisconsin has several monitoring sites, Green Bay, Milwaukee and Madison, that have measured violations of the new 24-hour PM2.5 standard base on 2005 through 2007 monitoring data. Based on this information and additional monitoring data EPA has designated three nonattainment counties in Wisconsin: Milwaukee, Racine and Waukesha Counties. Wisconsin is currently working on a comprehensive plan with Illinois, Indiana, Michigan and Ohio to address ozone, PM2.5 and haze problems. DNR's analysis indicates that the problem is regional in nature and the most effective way to deal with the problem is to limit emissions of SO_2 and NO_x on a regional basis. NO_x comes from combustion in cars, trucks, off-road equipment, power plants and industrial sources. SO_2 comes primarily from coal combustion in power plants and industrial boilers.

Up-to-date monitoring data and monitor address information is available from the DNR web site at http://dnrmaps.wi.gov/wisards under the "Reports" and "Find Location" tabs.

Section 110 CAA requires the state to develop State Implementation Plans (SIPs) which identify how the state will attain and maintain national ambient air quality standards (NAAQS) and meet other Federal air quality regulations.

Section 112 identifies 188 hazardous air pollutants; the EPA has focused their attention on 33 of the 188 pollutants at this time. *Five of these are emitted from biomass burning: Acetaldehyde, Acrolein, 1,3 Butadiene, Formaldehyde, and Polycyclic organic matter.* While this section focuses control requirements on major and minor stationary air pollution sources, the State and EPA are trying to determine the risk to the public from all air toxic emission sources *including biomass burning.*

Sections 160-169 provide for the prevention of significant deterioration of air quality in those areas of the county which currently have air quality concentrations which are better than the standards set under Section109.

Section 169A provides visibility protection for the mandatory Federal Class I areas There are no Class I areas in Wisconsin where visibility is an air quality related value. However, Wisconsin must submit a plan to limit the effects of our sources on visibility on any Class I area. The closest Class I areas are in Michigan and Minnesota; i.e.. Seney National Wildlife Refuge and Isle Royale National Park in Michigan, and Voyageurs National Park and Boundary Waters Canoe Area Wilderness in Minnesota.

Section 176 (c) prohibits Federal Agencies from permitting, approving, providing financial assistance, or supporting in any way an activity which does not conform to an EPA approved State Implementation Plan. This section of the Act only applies to federal agencies. However, a federal agency's prescribed burn emissions are presumed to conform to these plans provided the burn is conducted under certified Smoke Management Best Management Practices (SMBMP), and thus no determination is required.

Section 319 directs EPA to promulgate regulations governing the review and handling of air quality monitoring data influenced by an exceptional event. These regulations were designed to codify a number of existing EPA policies into a rule. That rule was published on March 22, 2007. The Rule provides that if exceptional events cause violations of the NAAQS, EPA would use its discretion not to re-designate an area as non-attainment.

One of those policies included in the Rule was the 1998 EPA Interim Air Quality Policy on Wildland and Prescribed Fire. The policy integrated two public policy goals: (1) to allow fire to function as

nearly as possible in its natural role in maintaining healthy wildland ecosystems, and (2) to protect public health and welfare by mitigating the impacts of air pollution emissions on air quality and visibility. The document identified significant procedural and legal benefits for the States and the users of wildland fire if they develop smoke management programs that are State certified. A State Smoke Management Program would establish a standard framework of those related procedures and requirements for managing smoke from prescribed fires. As a result of the new Exceptional Events Rule, EPA has committed to revise the Interim Policy, which will be forthcoming.

The Rule defines an exceptional event as an event that:

- Affects air quality
- Is not reasonably controllable or preventable
- Is an event caused by human activity that is unlikely to reoccur at a particular location
- Is a natural event

Examples of Exceptional Events are:

- Chemical Spills and Industrial Accidents
- Structural Fires
- Exceedances due to Transported Pollution
- Exceedances due to a Terrorist Attack
- Natural Events:
  - Volcanic & Seismic Activities
  - Natural Disasters & Associated Clean-up Activities
  - High Wind Events
  - Wildfires
  - Stratospheric Ozone Intrusions

The rule states that wildfires will be treated as natural events.
Prescribed fires managed for resources benefits may qualify for exceptional events if they meet certain criteria:

- "Unlikely to recur at the same location" and "not reasonably controllable or preventable"
- Where State certifies that a smoke management program or basic smoke management practices, were in place

EPA's handling of data from all other fires will continue to be addressed under the Interim Air Quality Policy for Wildland and Prescribed Fires.

Agency Authority
The Wisconsin Department of Natural Resources (WDNR) has the authority to implement and enforce Federal regulations related to air quality standards.

The WDNR maintains the air monitor system throughout the state. If an air monitor in the state records a violation of the NAAQS, then the area in violation of the standard is designated as "non-attainment" area. As required by Section 110 of the CAA, the state must submit a SIP to the EPA identifying what measures the state will take to reduce emissions affecting the area in order to meet and maintain compliance with the standard. Each plan shall include "enforceable emission limitation and other control measures" as required by Section 110. This would apply to facilities and sources that contribute to the violation of the standard. Construction and modification of stationary sources within non-attainment areas would be subject to emission offset regulations which require any new emissions to obtain emission offsets from existing air pollution sources. This requirement is designed to result in a net emission decrease to help bring the area back into attainment.

By implementing the requirements of a SIP that has EPA approval, the WDNR enforces compliance with air quality standards within the State of Wisconsin. Regulatory instruments that may be

included in a SIP in order to return an area to compliance with an air quality standard, include statutes, rules, orders, or permit conditions. If any of these become part of a federally approved WI SIP, the measure would become both State and Federal enforceable

Wisconsin is currently working to develop a Regional Haze SIP and $PM_{2.5}$ SIP as a member of the Midwest Regional Planning Organization (RPO) which includes Michigan, Ohio, Indiana, and Illinois. The projects underway by the Midwest RPO include visibility monitoring, data analysis, photochemical modeling, and engineering analysis of selected large $PM_{2.5}$ emitters in the region.

Appendix B

Managing Prescribed Fire in Wisconsin

Basis for Developing Smoke Management Best Management Practices (SMBMP)
The purposes of the SMBMP are directly related to the mitigation of any public health, nuisance and safety hazards posed by smoke intrusions into populated areas and roadways. The goals are to prevent deterioration of air quality and National Ambient Air Quality Standards (NAAQS) violations, and address visibility impacts on mandatory Class 1 Federal areas. The NAAQS referred to here are for particulate matter (PM) less than 2.5 microns ($PM_{2.5}$) and PM less than 10 microns (PM_{10}) in diameter.

The reasons SMBMP are being developed for Wisconsin are:

1. There has been an increase in the use of prescribed fire in Wisconsin.

Table A1 identifies a trend of increased use of prescribed fire in Wisconsin. This follows a nationwide trend identified by federal and state land managers. This increase of prescribed fire has strong ecosystem and landscape management implications to increase biodiversity and productivity.

2. To utilize a voluntary program to prevent PM NAAQS violations related to emissions from prescribed fire managed for resource benefits.

Implementation of SMBMP by land management agencies, organizations and the private sector should reduce potential emissions and smoke impacts from prescribed fires so that emissions do not result in “non-attainment” status with NAAQS and state air quality standards. The EPA Interim Guidance document explains that states which implement a certified SMP and do violate the PM_{10} or $PM_{2.5}$ standards will not have areas designed as “non-attainment”, if the State demonstrates that prescribed and/or wildland fire significantly contributed to the concentration of pollutants that exceeded the standards. This incentive by the EPA for implementation of a Smoke Management Plan is important if an area of the state were to violate the air quality standards due to smoke produced by prescribed burning.

The EPA Exceptional Events Rule published on March 22, 2007 states that all wildfires will be considered as natural events and will not be counted in determining an areas attainment or non-attainment status. The impact of prescribed fires may be discounted if the burn was conducted under a certified Smoke Management Plan or the burner was using basic smoke management practices (as defined by the applicable air quality regulatory agency).

3. The EPA Regional Haze Rule to protect and improve visibility in mandatory Class I areas the Lake States.

Section 169A of the Clean Air Act Amendments (CAAA) of 1977 sets forth “the national goal of preventing any future, and remedying any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from man-made air pollution.” The EPA rules issued in 1980 included language directed at those sources “reasonably attributable” to visibility impairment. With the addition of section 169B of the CAAA of 1990, congress addressed “regional haze” visibility impairment in the nation’s national parks and wilderness areas. The EPA determined that all 156 listed mandatory Class I areas across the nation demonstrate impaired visibility based on monitoring data from the Interagency Monitoring of Protected Visual Environments (IMPROVE). This includes the Class 1 areas of Seney National Wildlife Refuge and Isle Royale National Park in Michigan, and Voyageurs National Park and Boundary Waters Canoe Area Wilderness in Minnesota. For the Class

I areas, in Minnesota and Michigan, smoke from Wisconsin prescribed fires have not been shown to be a significant contributor to visibility impairment.

EPA published their final Regional Haze Rule on July 1, 1999 (64FR35714). This rule is directed at man-made air pollution sources that have the potential to cause or contribute to visibility impairment including: 1) stationary sources (industry), 2) mobile sources (vehicles), 3) area sources (gas stations, dry cleaners, etc.), and 4) the use of managed fire. Of the pollutants most responsible for haze (nitrates, sulfates, soil material, organic carbon, and elemental carbon), nitrates, organic carbon and elemental carbon are produced by vegetative burning. The regional haze program goal is to show continued improvement in monitored visibility in Class 1 areas and restore natural background conditions by 2064.

Other factors that do not apply to Wisconsin at this time but are “strong indications” that a smoke management plan is necessary are listed in the EPA “Interim Air Quality Policy on Wildland and Prescribed Fires” issued April 1998. These include any of the following if they result from fire use:

1. Citizens increasingly complain of smoke intrusions.

2. The trend of monitored air quality values is increasing (approaching the daily or annual NAAQS for $PM_{2.5}$ or 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}.

4. Fires in the area significantly contribute to visibility impairment in mandatory Class I Federal areas.

Appendix C
Smoke Production and Dispersion

Overview and Definition of Smoke Dispersion

Information pertaining to smoke dispersion is an important element of these SMBMP. Smoke dispersion is directly related to ventilation, which is the process within the atmosphere that mixes and transports smoke away from its source. Ventilation is a function of atmospheric stability, mixing height and transport winds. Mixing height is defined as the upper limit of an unstable mixed layer, in which upward and downward exchange of air occurs. In theory, the mixing height represents the level that smoke will rise to before spreading out horizontally. Transport wind is defined as the arithmetic average of the wind speed and direction within the mixed layer. Transport wind should provide a basic estimate of the movement of the smoke column as it advects out of the source region.

Just as various indices are used to estimate fire behavior, a ventilation index has been developed to estimate the lower atmosphere's ability to diffuse and disperse smoke. The Ventilation Index (also known as the Dispersion Index) is calculated by multiplying the mixing height (feet) by the transport wind (knots). A high Ventilation Index usually means that smoke will disperse in an efficient manner. A low Ventilation Index usually means that the dispersion of smoke in the lower atmosphere will be hindered. Caution should be used when interpreting the Ventilation Index, as the values can sometimes be misleading. For instance, a high Ventilation Index can be produced with either a high transport wind and low mixing height or a low transport wind and high mixing height. In both of these situations, smoke dispersion may still be hindered.

Table C1

Ventilation Index	Dispersion Category
0 – 12,999	Poor
13,000-29,999	Fair
30,000 – 60,000	Good
60,000 or greater	Excellent

Smoke dispersion information is available on the Fire Weather Planning Forecast (FWF), which is issued twice daily during the fire season at 7 am and 3 pm. Average mixing height and transport wind for the noon to 6 pm period are provided for the daytime periods (through day 2) in the Fire Weather Planning Forecast. The Ventilation Index, which is labeled as *smoke dispersal* in the FWF, is also averaged between noon and 6 pm, and is provided for the daytime periods of the forecast through day 2. Average values are used in order to provide a more representative estimate for prescribed burn projects, which may be started at varying times of the day (depending on the agency, type and size of the project). Fire Weather Planning Forecasts are posted on all local National Weather Service (NWS) websites. Smoke dispersion forecasts are also available as part of a spot forecast request.

Climate Factors that Influence Smoke Dispersion in Wisconsin

Wisconsin resides in the humid continental climate region, due to its interior location in the mid-latitudes of North America. The state lies in the boundary zone between many different air masses, including those of polar and tropical origin. As a result, Wisconsin experiences highly variable weather conditions and large seasonal changes in temperature. Weather conditions are most variable during the spring and fall months, when the jet stream migrates across the Great Lakes, resulting in strong storm systems tracking through the region. Lake Superior and Lake Michigan strongly influence local weather conditions near their respective shorelines in northwest and eastern Wisconsin.

Here are some more detailed explanations of the various factors that influence smoke dispersion potential in Wisconsin:

Air Masses and Frontal Systems are the main factors that influence day-to-day variations in smoke dispersion. There are five different types of air masses that affect the United States, including continental polar, continental arctic, continental tropical, maritime polar and maritime tropical. Wisconsin can be affected by all of these air masses during the course of a fire season, but is most commonly affected by continental polar, maritime polar and maritime tropical air masses. Continental polar air masses, which arrive from northern Canada, are usually cool, dry and stable, and sometimes result in low mixing heights and poor smoke dispersion due to the presence of a subsidence inversion. Maritime polar air masses form over the northern Pacific Ocean region, where they take on their typical cool, moist and unstable characteristics. However, these air masses usually lose most of their moisture as they ascend the west slopes of the Rocky Mountains, and warm as they descend the east slopes. By the time they arrive in Wisconsin, they are usually dry, mild and unstable. As a result, mixing heights are typically quite high in air masses of Pacific origin. Maritime tropical air masses, which originate from the Gulf of Mexico, are usually warm, moist and unstable.

Frontal systems can also have a significant effect on smoke dispersion. Cold fronts are usually accompanied by windy and unstable conditions, which provide for excellent smoke dispersion. Conditions are quite variable with warm fronts, with stable conditions and poor smoke dispersion expected north of the front, and unstable and windy conditions to the south.

Latitude, which controls the sun angle and length of the day, is responsible for seasonal temperature contrasts. Mid-latitude locations such as Wisconsin experience sharp changes in seasonal temperatures due to widely varying sun angle and day length. These temperature changes can significantly impact smoke dispersion. For example, mixing heights are typically lowest during the winter months, since daytime heating is limited due to low sun angle, short day length and snow covered ground. During the spring and summer, increased solar heating due to a high sun angle and longer day length is usually sufficient to mix out low level inversions, resulting in higher mixing heights and more effective smoke dispersion.

Lake Superior and Lake Michigan have a significant impact on smoke dispersion, especially during the spring and summer months. Lake breezes, which frequently develop in northwest and eastern Wisconsin from April through August, often result in poor smoke dispersion near the lakeshore. Lake breezes typically form during the late morning or early afternoon, become strongest during the mid to late afternoon, then weaken by early evening. On most days, the lake breeze front will only push inland 5 to 10 miles, but in extreme cases, may move inland 50 miles or more. Stable conditions develop as the cooler marine air penetrates inland, forcing warmer air aloft. In addition to smoke dispersion concerns, shifting winds associated with a lake breeze front can occasionally cause fire control problems.

Upper Level Disturbances, also known as upper level troughs of low pressure, often result in improved smoke dispersion as they pass through the western Great Lakes region. These disturbances, which are usually accompanied by pockets of cold air aloft, often produce windy and unstable conditions, and help to generate large scale rising motion in the atmosphere.

Weather Patterns that Affect Smoke Dispersion in Wisconsin

Wisconsin usually receives good ventilation throughout most of the fire season. During the months of April through October, solar radiation is usually strong enough to either mix out or lift inversions

that are near the surface. However, there are some typical seasonal weather patterns that cause smoke dispersion problems.

- During the early spring and late fall, strong Canadian high pressure systems often sag into the northern Great Lakes region and persist for several days. These Canadian highs typically have strong subsidence inversions, which gradually lower toward the surface, leading to poor smoke dispersal. Ventilation is especially poor when widespread low clouds (stratus) are present. The low clouds typically form in two ways; either due to low level east winds advecting marine moisture off of Lake Michigan, or due to the presence of a warm front over Iowa and northern Illinois, which lifts warm, moist air from the Gulf of Mexico over the top of the cooler Canadian air mass. The poor smoke dispersal is the net result of low mixing heights (generally 1,000-2,000 feet) and light winds.
- Persistent (lasting up to a week or more) summertime high pressure systems accompanied by a large blocking ridge of high pressure aloft can produce significant smoke dispersion problems. Although daytime mixing heights are often sufficiently high, transport winds are typically too light to support efficient smoke dispersion. The stagnant conditions eventually lead to reduced visibility and poor air quality, especially during the nighttime and early morning hours, when smoke particles aloft fall back to the surface.
- Radiation inversions (also known as nocturnal inversions), which develop as the earth's surface cools at night, can trap smoke near the ground during the nighttime and morning hours. Radiation inversions can occur throughout the year, and typically form on nights when skies are clear and winds are light. Summertime radiation inversions tend to be shallower, and usually mix out earlier in the morning, than those that develop during the spring and fall.
- Inland intrusions of cool, stable marine air associated with lake breeze fronts (or persistent onshore winds) can significantly hinder smoke dispersion during the spring and summer months. Lake breeze fronts are most common on days when winds at the surface and aloft are light. Lake breezes that develop near Lake Superior in northwest Wisconsin typically have a northerly component to their wind direction, while those that develop near Lake Michigan (and the bay of Green Bay) have an easterly component. Although a lake breeze front will typically remain within 5 to 10 miles of the lake during the early to mid afternoon, they can occasionally penetrate well inland (50 miles or more) before weakening during the late afternoon or early evening hours.

Appendix D
Guidance for Use of the Ventilation Index and Dispersion Tables

The Ventilation Index (also known as the Dispersion Index) is calculated by multiplying the mixing height (feet) by the transport wind (knots). A high Ventilation Index usually means that smoke will disperse in an efficient manner. A low Ventilation Index usually means that the dispersion of smoke in the lower atmosphere will be hindered.

Table D1

Ventilation Index	Dispersion Category
0 – 12,999	Poor
13,000-29,999	Fair
30,000 – 60,000	Good
60,000 or greater	Excellent

Note: In using the ventilation index, exercise caution with high transport wind speed and low mixing height or low transport wind and high mixing height. Either combination may result in a false representation of an acceptable category, which can result in smoke dispersion problems and potential control problems.

When utilizing the ventilation index it is important to consider the total fuel load being burned, both in terms of the fuel loading (tons of fuel per acre) and the total area to be treated. The proximity of downwind smoke sensitive areas to the burn unit should also be considered, so that in general the lower the expected total fuel consumption and the farther away from smoke sensitive receptors, the lower the ventilation index can be. Additionally, practices that reduce the total fuel load available for consumption can lower the acceptable dispersion category either by reduction of fuel, or acres to be treated.

Two methods that can be utilized for mitigation of smoke impacts during the burn planning process are as follows:

Method A: This method may be used as a general guide to use the Ventilation Index in combination with a smoke screening map to screen for sensitive downwind receptors. It is recommended for those burn units with low to moderate potential for smoke impacts.

1. From the Daily Burn Unit Size chart (Table D2) select the size of the planned burn unit* in acres.
2. Determine the general fuel category which best represents the majority of the burn unit.
3. On a map of the area locate the sensitive downwind receptors that could be impacted by smoke produced by the burn unit.
4. Use the Dispersion Category charts (Table D3) and determine the minimum distance which a burn should take place upwind of a sensitive receptor on a certain Dispersion Category day.

Note: These are voluntary guidelines which may vary based on the local unit's definition of smoke sensitive receptor and the ability to mitigate potential smoke problems by instituting traffic controls when smoke could impact major roads or by burning under fuel moisture conditions which limit consumption of heavier fuels.

Note: Use of these charts assumes no more than one burn unit within a 5 mile radius.

DAILY BURN UNIT SIZES – Table D2

Small	<50 acres
Medium	50 – 150 acres
Large	150-500 acres
Landscape	500 + acres

Distances to Smoke Sensitive Areas (from MN SMP)– Table D3

General Fuel Category	Daily Fire size (acres)*	Dispersion Index Category	Minimum dist. to downwind smoke sensitive areas (miles)
Single large pile or Scattered small piled fuels	NA	POOR	0.25
	NA	FAIR or BETTER	No limitation
Grass or Leaf litter	< 50	POOR	0.25
	< 50	FAIR or BETTER	No limitation
	50 - 150	POOR	No burning
	50 - 150	FAIR or BETTER	No limitation
	150 - 500	POOR	No burning
	150 - 500	FAIR	0.25
	150 - 500	GOOD or BETTER	No limitation
	500+	POOR	No burning
	500+	FAIR	0.75
	500+	GOOD	0.50
	500+	EXCELLENT	0.25
Timber, slash, or piled fuels	< 50	POOR	No burning (See above exception for pile(s))
	< 50	FAIR	0.50
	< 50	GOOD or BETTER	No limitation
	50 -150	POOR	No burning
	50 - 150	FAIR	0.50
	50 - 150	GOOD or BETTER	No limitation
	150 - 500	POOR	No burning
	150 - 500	FAIR	0.75
	150 - 500	GOOD	0.50
	150 - 500	EXCELLENT	0.25
	500+	POOR	No burning
	500+	FAIR	1.0
	500+	GOOD	0.75
	500+	EXCELLENT	0.50

Note: On Poor Category days no burning is suggested within ¼ mile of any downwind smoke sensitive area and is not recommended in general.

As an example, for a 500 acre burn in grass fuels, a minimum distance that a burn should occur upwind of a sensitive receptor would be: greater than 0.25 miles with Excellent Dispersion, greater than 0.5 mile with Good Dispersion, greater than 0.75 miles with Fair Dispersion and there should be no burn under Poor Dispersion.

Method B: Recommended for Complex Prescribed Burns where there is a high potential for smoke impacts.

1. Estimate the fuel loading for the area to be burned. This may be done formally, utilizing site-specific survey data if available or by consulting the fuel model information found in: *Aids in Determining Fuel Models for Estimating Fire Behavior,* or *Standard Fire Behavior: A Comprehensive Set for Use with Rothermel's Surface Spread Model* or the digital photo series at http://depts.washington.edu/nwfire/dps/.
2. Determine the acreage to be burned in one day.
3. Estimate the expected fuel consumption using hand calculations or computer models such as FOFEM or CONSUME. Selection of higher fuel moistures (such as higher 100 and 1,000 hour fuel moisture), which should reduce the fuel available for consumption, should be factored into the calculations.
4. Determine the total PM10 and PM2.5 emissions per day based on outputs from #3.
5. Locate downwind sensitive receptors that could be impacted from your smoke.
6. Utilize a dispersion computer program to screen for the potential to exceed ambient air quality standards.

Mapping guidance to identify the closet smoke sensitive target and distance from the prescribed fire.

1. Locate on a map the prescribed fire and all potential smoke sensitive targets, plus areas known to already have air pollution problems.
2. Determine the wind direction that should have the least impact on smoke sensitive targets.
3. Draw a line representing the centerline of the path of the smoke plume using the wind direction chosen in the previous step.
4. Determine the distance from the edge of the prescribed fire to the nearest smoke-sensitive target.
5. To allow for horizontal dispersion of the smoke, as well as shifts in wind direction, draw two other lines from the burn at an angle of 30 degrees from the centerline.

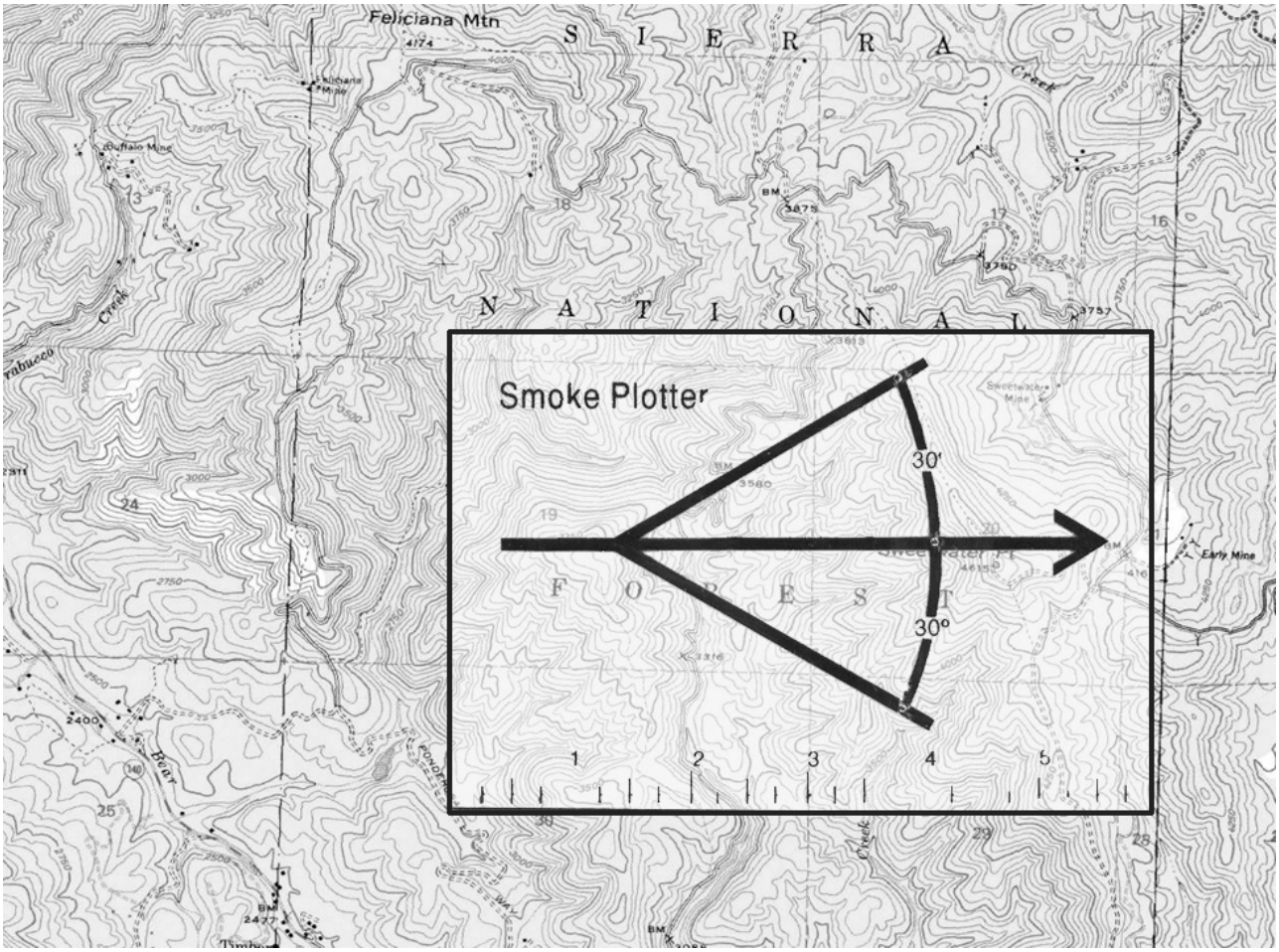


Figure D1 Smoke Plotter (NWCG RX 410)