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FOREST FIRES AND SMOKE - IMPACTS ON AIR QUALITY AND HUMAN HEALTH IN THE USA

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ABSTRACT

Scientific and regulatory interest in the air quality impacts of forest fire smoke (both prescribed and wildfires) followed the implementation of the 1970 Clean Air Act amendments. Attention on forest fires became more focused as a series of new amendments were enacted to protect the air quality and visibility of "natural" areas; and as the particulate matter air quality standards on "inhalable" and "respirable" particles were tightened, Forest fires have been shown to be a significant source of these small particles. Resource managers are 'adapting to these regulations by adopting Smoke Management strategies which include sophisticated decision support systems. Currently, the Environmental Protection Agency (EPA) (with pubiii & private input) is developing a national "Wildland Fire/Air Quality" policy which attempts to integrate two public policy goals (1) to allow fire to function in its natural role to maintain healthy ecosystems and (2) to protect public health and welfare by mitigating smoke impacts.

Heightened concern about the occupational health effects of forest fire smoke followed the 1988 Yellowstone fire when thousands of firefighters experienced respiratory probiems. In 1989, a series of studies were commissioned related to the effects of immediate and long-term exposure to forest fire smoke, While ail the studies have not been completed, results to date indicate that the incidence of exposure which exceed current Occupational Safety and Heaith Administration (OSHA) standards were relatively low (fewer than 5 percent of cases). As research continues, strategies for risk management are being developed to reduce smoke exposure and monitor worker health.

INTRODUCTION

Fire has always been an integral part of many wildland (forest, range and grassland) ecosystems in the United States. However, since the turn of the century; fire has been suppressed in the nation's wildlands to protect public safety, property, and to prevent what was thought to be the destruction of our natural resources. The damaging effects of excluding fire has mounted gradually over decades and is now widely recognized as a serious forest health probiem. Fire exclusion practices have resulted in forests, shrub lands, and: grasslands to become plagued with a variety of problems, including overcrowding, resulting from the encroachment of species normally suppressed by fire; vulnerability of trees to insects and disease; and inadequate reproduction of fire dependent species, In addition, heavy accumulation of fuels (such as dead vegetation on forest floors) can cause fires to be catastrophic, which threaten firefighter and public safety, impair forest and ecosystem health, and degrade air quality. (1)

Federal land managers have recognized this wildland health problem and are considering a seven-fold increase in the use of prescribed (managed) fire by the year 2005 (from 280,000 hectares to 2,000,000 hectares annually). (2) This increased use of fire across the United States brings with it concerns about the impacts of smoke on both ambient air quality (public health and visibility) and occupational air quality (firefighter health).

Wildlands. Generally, "wildland ecosystems" include forests, grasslands and shrub or brush lands. The term "wildland," as used in EPA's Interim Air Quality Policy on Wildiand and Prescribed Fires (1) refers to an area of limited development having the following characteristics:

1. Development is generally limited to roads; railroads, power lines, and widely scattered houses or other buildings.
2. The land is not cultivated (e.g., the soil is disturbed less than once in ten years) or fallow. It may be neglected altogether or managed for purposes such as wood or forage production, wildlife management, recreation, wetlands, or protective plant cover.
3. The land is not in the U.S. Department of Agriculture (USDA) Conservation Reserve Program.

In a separate forum, USDA has established the Agriculture Air Quality Task which will address air quality issues related to open burning on agricultural lands.

Prescribed Fires, Wildland Fires and Wildfires. A planned or "prescribed" fire is any fire intentionally ignited to meet specific land management objectives (e.g., to reduce flammable fuels, such as the accumulation of brush, logs, etc. on forest floors; or to help restore ecosystem health). Prescribed fires are pre-planned ignitions, with predetermined boundaries. They are conducted only under certain weather conditions when flame length and heat can be controlled Generally, managers must obtain approval of prescribed fires or burn plans from applicable state agencies before conducting burns. "Wildland fires," like prescrii fires, are managed to benefit resources or the environment. Wiidland fires are usually ignited naturally (i.e., by lightening) in areas where the land use plan calls for fire. The wildland fire must meet a prescription and be managed just like a prescribed fire. Wildfires on the other hand are simply unwanted wiidiand fires.

HISTORY OF AIR QUALITY LAWS AND REGULATIONS AND PRESCRIBED/WILDLAND FIRES

1955 to 1981 - Emerging Issues (3, 4)

The first federal legislation related to clean air was enacted in 1955, but was essentially restricted to research into the nature of the Nation's air pollution problems. The 1963 Clean Air Act (CAA) authorized grants to state and local agencies to assist in control programs. The 1967 Air Quality Act gave citizens the right to participate in program planning through public hearings. In many communities, citizens seized this opportunity to forcefully and effectively advocate clean air. At this point Federal involvement and control were very limited. The effectiveness of the laws depended on state initiatives that never seemed to materialize.

In 1970, CAA amendments 'strengthened air management and control by shifting emphasis from State to Federal initiatives, including the following:

1. The EPA was established and charged with delineating air quality control regions based on considerations of climate, meteorology, topography, urbanization and other factors affecting air quality in each area. Some 250 regions were established.
2. EPA was required by law to develop regulations describing national ambient air quality standards (NAAQS) for air pollutants that had an adverse effect on public health (primary standards) and public welfare (secondary standards). In 197 1, the 6 criteria pollutants established were: particulate matter, sulfur oxides, hydrocarbons, carbon monoxide, photochemical oxidants, and nitrogen oxides. Lead was added in 1978.
3. The states were given responsibility for enfiiing the standards and for controlling pollution at its source. Each State was required to develop a state implementation plan for maintaining air quality within the national standards. As states inventoried their open burning pollution sources, questions on forest and agriculture burning began to surface. How much open burning was taking place? 'Where? Why? Were there any alternatives? What kind and how much smoke was emitted? States could adopt standards and controls more stringent than national standards but not less stringent. If a state failed to submit a satisfactory plan, EPA had the authority to write its own plan for the state.
4. Each agency of the Federal government had to comply with Federal, state and local requirements concerning control and abatement of air pollution.
5. Any citizen could bring suit against a person, corporation, or agency alleged to be violating an emission standard or other limitation applicable under the Act. Citizens could also sue EPA for failure to perform an action required by the 'Act.
6. Where state or local authorities had not acted to stop the emission of air pollutants, EPA could take action including filing a civil action suit.

As progress was made in cleaning the air over urban areas through engineering solutions such as catalytic converters, public attention began to expand to rural air pollution problems . In 1972, the Sierra Club filed suit which led to a court order. The suit required EPA to disapprove all state air quality plans that did not contain provisions for the prevention of significant deterioration (PSD) in areas where'the air quality was cleaner than the national standards.

In response to the suit, EPA in December 1974 issued PSD regulations for stationary sources of particulate matter and sulfur oxides. These regulations were designed to prevent deterioration of air quality in many areas where the air was relatively clean. They also protected the air quality of natural areas, such as National Parks and Wilderness Areas, from

pollution from major stationary sources. Pollution from nonstationary sources such as agricultural and forestry burning, was mentioned in public meetings but did not appear in the regulatory language.

Three classes were established for control of significant deterioration:

Class I. Pristine areas where virtually no deterioration of air quality would be allowed.

Class II. Relatively clean areas which would permit moderate deterioration of air associated with limited and managed growth.

Class III. Areas that would be allowed to deteriorate up to the NAAQS to permit more intensive development.

In 1977, the CM was amended to strengthen efforts associated with the nondegradation of air quality. Important elements included:

1. Expanded PSD Program. An additional national goal, "the prevention of any future and the remedying of any existing impairment of visibility in mandatory Class I Federal areas was added. Previously, temporary emission sources, such as prescribed burning, were not mentioned in the regulatory language and were, therefore, assumed to be excluded from PSD requirements. When protection of visibility became a goal, prescribed burning began easing into the regulatory debates. Federal land managers were required to take "affirmative action" to protect air quality in the Class I areas. Many land managers could see themselves in the position of defending and implementing prescribed burning programs while at the same time taking "affirmative action" against proposed industrial development which might emit increments of particular matter.
2. Nonattainment Areas. With the help of the states, EPA published a list of geographical areas that were not meeting the NAAQS. The only apparent means for allowing industrial development in these areas was to adopt EPA's emission offset policy. New sources were to obtain sufficient reductions (offsets) in emission from existing sources in the area. Prescribed burning and other so-called natural sources such as terpene emissions from trees were discussed at conferences for possible use as emission offsets.
3. Inhalable Particulate Matter. The 1977 amendments also directed EPA to review the existing NAAQS and, if necessary, modify them Review led to the consideration of a new inhalable particulate matter standard which included particles smaller than I5 micrometers. Because prescrii burning produced particles in thii size category it was expected to receive renewed attention as new state-by-state inventories were developed for sources of inhalable particles.

Prescribed burning began to ease into the Federal regulatory process as EPA began to examine all potential sources of visibility impairment as mandated by Congress. In 1979, as a preliminary step to regulating visibility, EPA prepared a comprehensive report to Congress which outlined the sources of visibility impairment and proposed methods to evaluate and control adverse impacts. The impacts from prescribed burning, especially slash burning in the Pacific Northwest, was carefully analyzed. The EPA report also noted that some alternatives to forestry burning did exist, especially for disposal of accumulated logging slash. EPA recognized, however, that practical alternatives to the use of fire for improving wildlife habitat and reducing fire hazards in some areas were not available.

The list of areas in which visibility was established as an important value was promulgated by EPA in November 1979. Preparation of the list was difficult and required extensive coordination with federal land managers and research scientists. Visibility values had to be identified before visibility could be defined objectively. The 156 areas that were recognized included 36 National Parks, 1 International Park 1 National Memorial Park, and 118 Wilderness Areas. On 30 November 1979, EPA published an Advance Notice of Proposed Rule-making in the Federal Register. Prescribed fire was listed, along with many industrial sources, as a contributor to visibility impairment. Publiccommentwasinvited and proponents of prescrii burning responded The comments focused on the ecological and economic basis for fire as well as existing state smoke management strategies which proponents felt precluded the need for additional federal constraints or regulations.

On 22 May 1980, EPA published proposed regulations on visibility. The language dealing with prescribed burning had moderated from a national regulatory approach to one which required each state to consider smoke management techniques as part of the long-term strategy to achieve the visibility goals. EPA openly acknowledged the benefits of some prescrii burning programs.

On 2 December 1980, EPA issued the final visibility regulations. It was now clear that EPA planned a slow, phased approach to the implementation of visibility regulations. Initial attention was given to the impact of welldefined plumes

originating from a single major source or group of well-defined sources. At the same time, research would continue into visibility concepts and methods for use in future phases which would deal with regional haze and long-range pollution transport problems. The immediate impact of the visibility regulation to prescrii burning is found in the section which requires 36 states containing Class I areas, "to consider at a minimum several factors during the development of its long-term strategy including . . . . smoke management techniques for agricultural and forestry management purposes including such plans as currently exist within the State for these purposes." This explicit language sharpened the focus on air quality impacts from prescribed burning by states that were only casually or passively interested in the past. Voluntary programs presumably could become mandatory in this process. The regulation called for the states to submit plans for protection visibility to EPA by September 198 1.

1981 To 1998 • Prescribed/Wildland Fires in the Spotlight

In July 1987, EPA revised the ambient air quality standard (NAAQS) for particulate matter. The old total suspended particulate standard (TSP) was replaced with a new indicator that includes only those small, inhalable particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers, the so called PM1 0 standard. This generated new interest and concern for all sources of small particles (primarily combustion sources) as states were mandated to revise their air quality State Implementation Plans (SIP's). Prescribed burning was placed in the regulatory spotlight because it was believed to be a significant source of PM 10 particles in several parts of the United States, especially in the West.

In 1990, the CAA was amended once again. These amendments required the EPA to publish a list of sources for a new list of 189 "toxic air pollutants" along with "Maximum Achievable Control Technology" (MACT) standards for each source category. It also called for "Best Available Control Measures" (BACM) for non-traditional sources of air toxins (including prescribed burning). (5) Prescribed burning was becoming more widely recognized as a significant source of particulate matter emissions nationally and a major contributor to visibility impairment in Federally designated Class I areas. And at this point, a largely unquantified contributor of air toxins.

In July 1997, new national ambient air quality standards for ozone and particulate matter were approved. This was the first update for ozone in 20 years and the first in 10 years for particulate matter. The new standard for particulate matter targets respirable particles less than 2.5 micrometers or PM2.5. The PM10 standards were also retained with a slight revision in the way that average concentrations were calculated This latest tightening of the PM standard was largely based on epidemiological studies that report consistent associations between exposure to fine particles (PM2.5) and human health problems (heart and lung), especially among children and the elderly. The biological basis for this association is largely unknown and opponents of the new rule have urged a better scientific foundation be developed before the year 2002 when states will be required to draft plans to meet the new health based standard. (6)

The aerodynamic diameter of most particles emitted from prescribed and wildland fires (as well as most combustion sources) is below 2.5 micrometers. Thus, this latest and more stringent PM standard comes at a time when strategies to achieve policy goals related to the Clean Air Act, the Threatened and Endangered Species Act, and other foresthealth issues are converging. Some have characterized this convergence as a potential "Head-on Collision" (7). Others have referred to it as "A Smoking Gun" (8). Still others have pointed to the attempts to reconcile what is "natural," and what is "man-caused" or antbropogenic, with regard to fires in our wildlands. (1) Which fires should be subject to the CAA laws and regulations? Will more frequent use of small prescribed tires decrease or offset the potential for health and resource impacts that come From large, uncontrollable wildfires? Are some wildfires really the indirect result of management actions (or lack thereof), and therefore more-man-induced rather than natural?

Fortunately, many of these paradoxical issues associated with prescribed and wildland fires are now being addressed by scientists, managers and administrators in a number of collaborative partnerships which includes both public and private sector participation. The most recent and most comprehensive new policy resulting from this collaboration was released by EPA in April 1998 as the "Interim Air Quality Policy on Wildland and Prescribed Fires." (1)

EPA INTERIM AIR QUALITY POLICY ON WILDLAND AND PRESCRIBED FIRES

On April 23, 1998 the EPA issued **an interim policy** for addressing public health and welfare impacts caused by wildland and prescribed fires that are managed for resource benefits. This is an interim policy for two reasons. First, the Agency is expecting recommendations on how to treat air quality impacts from agricultural burning from the U.S.

Department of Agriculture's Air Quality Task Force. Second, until the final rules for implementing EPA's Regional Haze Program are promulgated, it is not possible to formulate final policy with respect to the impact of wildland and prescribed fires on regional haze. What follows, are excerpts from the 38 page policy. (1)

Purpose of the Policy

This policy was prepared in response to plans to significantly increase the use of wildland and prescribed fires to achieve resource benefits in many forest and range lands throughout the United States. Many wildland ecosystems are considered to be unhealthy as a result of past management strategies. The absence of fire has allowed both native and non-native plant species to proliferate, understory vegetation to become dense, and insect infestations to go unchecked. Wildland owners/managers plan to significantly increase their use of fires to correct these unhealthy conditions, and to reduce the risk of wildfires. The largest increases are expected on Federal lands in western states. In the southeastern states, fire has long been a management tool widely used by many public and private wildland owner/managers. Federal land managers arid others also plan to significantly increase their use of fire in this region above current annual levels, to help with the recovery and sustainability of the fire dependent longleaf pine ecosystems found throughout the southeast.

This EPA policy statement integrates 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 pollutant emissions on air quality and visibility.

The policy provides guidance on mitigating air pollution impacts caused by fire. It also identifies the responsibilities of wildland owners/managers and air quality managers and urges them to work together to coordinate fire and smoke management activities, and establish emergency action programs to mitigate the unavoidable impacts on the public. **Thii policy is not intended to limit opportunities by private wildland owners/managers to use fire so that burning can be increased on publicly owned wildlands. Thoughtful use of fire by all wildland owners/managers is promoted to maintain wildland ecosystems.**

Scope of The Policy

The EPA does not directly regulate the use of fire within a State or on Native American (tribal) lands. The EPA's authority is to enforce the requirements of the Clean Air Act (CAA). The CAA requires States and tribes to attain and maintain the national air quality standards adopted to protect public health and welfare. This new policy recommends that States/tribes implement smoke management plans (SMP's) to mitigate the public health and welfare impacts of fire managed for resource benefits. While SMP's will also mitigate nuisance smoke intrusions (smoke on roads, highways, airports, etc.), nuisance issues have been left for the individual air quality agencies to address.

This policy applies to all wildland and prescribed fires managed to achieve resource benefits on public, tribal and privately owned wildlands, regardless of the cause of ignition (e.g., lightning, arson, accidental, land management decision, etc.) or purpose of the fire (e.g., natural -resource management; hazard reduction, etc.).

The goals of public land management agencies vary, but are generally to develop, maintain and enhance wildlife habitat; protect endangered plant and animal species; preserve and protect cultural resources, scenic vistas and wilderness; provide for recreation; and to sustain production of natural resources. The goals of private wildland owners/managers may be sustained production of natural resources, preservation of wildlife habitat, improved grazing conditions, etc. The goals of tribal wildland owners/managers are generally similar to public land management agency goals, but may also include aspects of private land owners. Another common goal of all wildland owners/managers is to minimize the potential for catastrophic wildfires that could result from heavy accumulations of vegetative fuels.

Wildland owners/managers have an array of tools, including fire, mechanical, and chemical (herbicide) treatments, that can be used to accomplish land use plans, depending on the resource benefits to be achieved. Several factors should be considered when selecting appropriate treatments. Those factors include the costs of treatment, the environmental impacts (e.g., air and water quality, soils, wildlife, etc.), and whether fire must be used to meet management objectives in fire dependent ecosystems. The best combination of treatments are those that meet management goals with the most favorable environmental impacts at the most reasonable costs.

This policy does not apply to other open burning activities, such as burning at residential, commercial or industrial sites; open burning of land clearing waste or construction debris. It also does not apply to open burning of agricultural waste, crop residue or land in the USDA Conservation Reserve Program. The EPA is working with the USDA Agriculture Air Quality Task Force to develop equitable policies for emissions from activities that could be classified as agricultural burning.

Description of the Policy

The policy encourages all those who conduct prescribed burning or who manage naturally-ignited fires to:

1. Notify air quality agencies of plans to significantly increase the use of fire.
2. Take air quality impacts of fire into consideration and take appropriate steps to mitigate the impacts;
3. Consider alternatives to fire which will meet the land management objectives.
4. Participate in the development of smoke management plans.

The policy emphasizes the importance of voluntary smoke management plans. **When burning for resource management benefits is carried out in accordance with these plans, and such burning contributes to violations of National Ambient Air Quality Standards (NAAQS) for PM2.5 or PM10, or causes visibility impairment in Class I areas, EPA does not plan to restrict burning activities, but rather will ask that the adequacy of the smoke management plan be expeditiously reviewed. If a smoke management plan is not developed, and burning activities are found to contribute to particulate concentrations above the NAAQS, EPA will force development and implementation of a mandatoiy smoke management plan and may redesignate these areas as nonattainment, which then imposes requirements for emission reductions.**

Smoke Management Programs (SMP's)

SMP's establish a basic framework of procedures and requirements for managing smoke from fires managed for resource benefits and are typically developed by States/tribes with cooperation and participation by wildland owners/managers. The purpose of SMP's are to:

1. Mitigate the nuisance and public safety hazards (e.g., on roadways and at airports) posed by smoke intrusions into populated areas;
2. To prevent deterioration of air quality and NAAQS violations.
3. To address visibility impacts in mandatory Class I Federal areas.

If a State&ii determines that a SMP is needed, they can adopt any type of program they believe will prevent NAAQS violations and address visibility impairment. For example, general fire safety regulations may establish basic parameters, such as wind speed, direction, location and distance to sensitive receptors, etc., within which fires can be ignited or a naturally ignited fire can be allowed to continue to **bum. States/tribes may allow wildland owners/managers to voluntarily notify them of fire plans or may require prior authorization. They may also exempt de minimis fires (fires that will cover fewer then X acres or consume less than Y tons of fuel, as established by the State/tribe) from meeting the regulations. Such** regulations leave **much** discretion to wildland owners/managers as to when to ignite fires, and what management strategy to follow with naturally ignited fires. States/tribes may exercise enforcement authorities when wildland owners/managers are found to have ignited the fire outside of the parameters of the rule, or not to have appropriately responded to air quality impacts caused by naturally ignited fires.

Generally fire regulations may be adequate for areas where fires managed for resource benefits rarely cause or contrii to air quality problems. However, when plans to use fire on a large scale could cause significant air quality impacts, or several wildland owners/managers within an airshed are expected to use fires concurrently, a more structured SMP requiring cooperation and coordination of fire activities may be required to minimize emissions and mitigate the air quality impacts.

Wildfire/Wildland Fire Distinction

High smoke concentrations attributable to wildfires (unwanted wildland fires) can be treated as due to a natural event under EPA's Natural Events Policy. **The Natural Events Policy provides that when areas violate the PM10 NAAQS due to a natural event, EPA will: (1) exercise its discretion not to redesignate areas as nonattainment if the State develops and implements a plan to respond to the health impacts of natural events; and, (2) redesignate nonattainment areas as attainment on a case-by-case basis, to discount (ambient air quality) data in circumstances where an area would be in attainment but for exceedances that result from uncontrollable natural events. The**

EPA plans to revise the Natural Events Policy to also cover PM2.5 NAAQS violations.

Prevention of Significant Deterioration (PSD)
The Clean Air Act requires States/tribes to consider provisions to prevent the significant deterioration of air quality in areas designated as attainment or areas unclassifiable for any of the NAAQS's. **"Significant deterioration" for any pollutant is defined as an unacceptable incremental increase in ambient concentrations above the baseline concentration for that pollutaut in an area.** PSD "increments" have been established for sulfur oxides, nitrogen oxides, and PM 10. However, no increments have yet been promulgated for PM2.5.

While fires managed for resource benefits generally are not subject to the issuance of a PSD permit, the emissions from such activities may affect the air quality in a PSD area. Under adverse conditions, the combined PM emissions from increased fire activities and from other sources could possibly result in ambient concentrations that exceed the allowable PSD increments for PM. Historically, EPA has often regarded fires managed for resource benefits to be temporary activities. The PM emissions resulting from fire activities differ from the PM emissions generated by most other sources because they are generally short-lived. That is, the burning generally is carried out infrequently at a specific location (once every 3-20 years) and the duration tends to be short (approximately l-2 days). Even with the proposed increased utilization of fire as a resource management tool, resulting PM emissions are expected to be relatively uncommon at a particular location and of short duration.

The EPA generally supports the concept of allowing States with approved State Implementation Plaus to exclude emissions caused by temporary managed fire activities from increment analysis, provided the exclusion does not result in permanent or long-term air quality deteriomtion. Nevertheless, the decision as to whether PM emissions from fire activities should be counted against the PSD increments for PM is a decision to be made by individual States. The EPA expects States to consider the extent to which a particular type of prescribed burning activity is truly temporary, as opposed to those activities which can be expected to occur in a particular area with some regularity over a period of time.

THE ROLE OF SCIENCE AND TECHNOLOGY TRANSFER

For almost 30 years the scientific community has been aggressively addressing a number of information gaps that surround wildland fire smoke and air quality issues. The result has been several hundred technical documents and scientific papers that can only be highlighted here. They include studies which address the following questions. What are the chemical and physical properties of smoke? How much smoke is produced, where and when? What are the factors which influence smoke production and changing characteristics of smoke down wind? How can you manage smoke, reduce emissions, predict and minimize impacts? What are the liability implications? What are the tradeoffs between prescrii fires and catastrophic wildfires? What are the visibility impacts of smoke? Ranging from regional haze impacts down to visibility impacts on roads and highways and other smoke sensitive areas. What is the role of fire in an ecosystems? Are there alternatives? What are the costs and benefits? What are the implications to the private sector? What are the health impacts of prescribed/wildland fire smoke?

In addition to filling science gaps, extension, education and other technology transfer efforts are needed to reach out to administrators, land and resource managers, workers, and the general public. Because smoke has no boundaries, the need for cooperation among Federal agencies and other public and private partners has been strongly embraced

A comprehensive list of references, white papers and conference summaries related to the Wildland fire science and technology questions posed above are available on the internet from the EPA Wildland Fire Issues Group web site (9) and from the Western State Air Resource Council (WESTAR) web site (10). WESTAR was founded in 1988 by the air quality agencies of 15 Western states to promote the exchange of information on air quality issues of common concern and to recommend policy and problem solving options that would be mutually beneficial.

Forest fires are known to form hundreds of compounds in the complex mix of gases and particles we call smoke. For simplifying purposes, the focus in this review up to this point has been on smoke particles or "particulate matter," which is known to cause essentially all of the wildland smoke problems and incidents that have been documented to date. (1,5,11,12) Carbon monoxide and other airborne toxins found in wildland smoke are more of a potential occupational health hazard for workers in or near the fire zone.

OCCUPATIONAL HEALTH HAZARDS OF WILDLAND FIRE SMOKE

The current plans to expand the use of prescriid fire in the United States has also raised concern about how the smoke from this expanded program will affect the occupational health of the workers who carry out the program. A variety of occupational exposure limits for some airborne smoke toxins exist; ranging from the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs), to the American Conference of Government Industrial Hygienists Threshold Limit Values (TLVs), and the National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limits (RELs). These limits are primarily based on exposure over an 8-hour workshift for an entire work career. However, in some cases Short-term Exposure Limits (STELs) and ceiling limits are also defined to control peak exposures for fast-acting toxins.

Early studies on wildland fire smoke in the 1970's and early 1980's was focused ahnost entirely on questions related to ambient air quality and the public health and welfare impacts. occupational health effects was simply not a high priority. This changed dramatically with the 1987 fires in northern California and the 1988 Yellowstone fires, when thousands of firefighters experienced acute respiratory problems from the smoke.

To address these concerns the interagency National Wildfire Coordinating Group (NWCG), related agencies, employee groups, and specialists in occupational medicine, industrial hygiene, toxicology, and risk management met in San Diego in 1989. They developed a study plan for determining the immediate and long-term effects of exposure to forest fire smoke.

The comprehensive plan proposed studies in five areas related to:

1. Emissions characterization.
2. Employee exposure.
3. Health effects.
4. Risk Assessment,
5. Risk Management.

The NWCG assigned the USDA Forest Service, Missoula Technology and Development Center (MTDC), Missoula, MT, to serve as the focal point for coordinating and communicating ongoing studies on this topic.

In 1997, MTDC organized a conference to review and report programs on each of the five related study areas and to develop recommendations for implementing a worker risk management plan. (9)

In summary, the conference participants concluded that while toxic emissions were present in smoke, the incidence of exposure in excess of OSHA PEL's was relatively low. Fewer than 5% of cases monitored in prescribed fires and even less for exposures in wildfires. It was also found that documented health effects from acute exposures were moderate and reversible. (9)

The studies also found that firefighters may occasionally exceed shift-average exposure limits for respiratory irritants (acrolein, formaldehyde and respirable particulate matter) and carbon monoxide (CO). The excessive exposures were significantly associated with fires in higher wind speed conditions which kept concentrations of smoke high near the breathing zone. (9) This same study found that simple, low cost CO dosimeters could be used effectively to monitor exposure to CO and to estimate exposure to other potentially hazardous products of incomplete combustion, Additional case studies of smoke exposure are needed because of the very high variability of fire/weather conditions coupled with a high variability of duties that are part of a firefighter work shift

A screening health risk assessment was also undertaken to address the health risks of chronic smoke exposure for wildland firefighters. (9) However, this study is incomplete because of the lack of toxicity values associated with respirable particulate matter. The study did conclude that adverse health effects are unlikely for other smoke toxins based on the current available data. The contribution of respirable particulate matter is being further evaluated.

Proposed recommendations for firefighters risk management which deal with smoke exposure included:

1. Changes in training and field tactics to minimize exposure on both prescribed and wildfires.
2. Pollutant monitoring (CO) to increase awareness and help limit exposure.

3. Health promotion and maintenance to maintain overall health of firefighters immune system and to avoid the spread of infection.
4. Medical surveillance to track exposure.
5. Further research on long-term effects of smoke exposure.

It was also concluded that respiratory protection should be considered only when other controls, such as training, tactics, and monitoring, fail to protect worker health and safety. It is hoped that monitoring will demonstrate that changes in training, tactics, and other elements of this program will further minimize the already low level of exposure.

Respirator evaluation and field testing continues on a limited pilot scale. Many experts feel that an effective respirator for wildland firefighters will need to be specifically designed for that application.

JOINT (INTERAGENCY) FIRE SCIENCE PROGRAM

The plan to address the United States forest and range health issues by the increased use of prescribed fire has posed new questions about information gaps and the state of readiness of all natural resource agencies. In 1998, Congress expressed a concern that "both the U.S. Forest Service and the Department of the interior lack consistent and credible information about the wildland fuels management situation and workload, including information about fuel loads, conditions, risk, flammability potential, fire regimes, locations, effects on other resources, and priorities for treatment in the context of the values to be protected." (2) Congress dii the Department of Interior (including the Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA), National Park Service (NPS), Fiih and Wildfire Service (FWS), U.S. Geological Survey (USGS)), and the Forest Service (FS) to establish a Joint Fire Science program to supplement existing fire research capabilities. The details of the new Joint Fire Science Program, summarized here is available on the internet at www.nifa.gov/joint_fire_sci/index.html. (2)

The program is designed to provide a scientific basis and rationale for implementing wildland fuels management activities, with a focus on activities that will lead to development and application of tools for managers-

The program plan addresses four issues critical to the success of the wildland fuels management and fire use program. These issues are:

1. The need to develop and implement consistent interagency fuels mapping and inventories with common classifications and resolution within ecosystems. This information will help managers identify the location of hazardous fuels, determine where fuels have accumulated beyond the historic range of variability, determine potential impact of current fuel conditions on fire regimes and ecosystem processes, determine where fire damages and costs are increasing, recognize the most risky fuel/fire regime components, set priorities for treatments, and determine the appropriate type and frequency of treatment.
2. The need to evaluate and compare fuels treatment practices and techniques, including prescribed fire, thiiing and other mechanical methods, increased utilization of biomass, and no treatment. The evaluations will assess cost effectiveness, social impacts, air quality and watershed impacts, ecological consequences, and potential effects on wildland tire size, severity, and cost.
3. The need to develop treatment schedules, determine the frequency of subsequent treatments, and coordinate treatment schedules among agencies. In developing treatment priorities and schedules, managers will need to consider the potential effects on other resources such as air and water quality, wildlife habitat, threatened and endangered species, and cultural values; on management activities, such as timber harvest, grazing, recreation, control of invasive, nonnative plants; and on costs, benefits, and risks associated with treatment and no treatment.
4. The need to establish compatible interagency processes and procedures for monitoring, evaluating, and reporting fuels treatments. This will allow managers to determine whether the fuels management program is meeting its goals and objectives, by regularly updating fuels maps and inventories, and allowing synthesis of information across geographic and agency boundaries.

The Joint Fire Science Program will establish the process and program oversight structure to identify and meet fire information and technological support needs for a national interagency wildlands fuels management program. The Governing Board of the program approved funding for 24 projects in 1998. The first 20 projects resulted from a Request for Proposals issued in June 1998. The other four are addressing other urgent needs including two projects which are addressing the social, ecological and economic consequences of the catastrophic 1998 Florida wildfires. All projects

involve multiple collaborators in both the public and private sectors. Funding level for the program for both FY98 and 99 is approximately 8 million dollars/yr. Funding in future years will be based on needs and priorities identified by the program Governing Board in consultation with a Stakeholder Advisory Group.

SUMMARY

1. Fire has always been an integral part of many wildland ecosystems in the United States. However, many decades of fire suppression has led to more and more catastrophic wildfires and more serious degradation of our fire dependent ecosystems.

2. Natural resource managers are proposing to dramatically increase the use of prescribed (managed) fire to lower the risk of wildfire and to restore health to fire dependent ecosystems. Federal land managers are suggesting a 7-fold increase by the year 2005.

3. Wildland fires produce significant amounts of respirable particulate matter (PM2.5). PM2.5 has recently been incorporated into the National Ambient Air Quality Standards by the Environmental Protection Agency (EPA). Smoke from fires also can contribute to regional haze and other visibility problems.

4. To help reconcile the planned expanded use of prescribed fire with the recently tightened PM standard, EPA has proposed a "Wildland Fire/Air Quality Policy." This policy in cooperation with public and private partners attempts to integrate two colliding public policy goals: (1) to allow fire to function in its natural role to maintain healthy ecosystems, and (2) to protect public health and welfare by mitigating smoke impacts.

5. The expanded use of fire has also raised new concerns about occupational health problems and risks from smoke to workers on or near the fires. To date, it is estimated that approximately 5 percent of 'exposure scenarios result in exceeding current OSHA occupational standards However, new risk management strategies have been proposed to mitigate acute exposures. Long term health impacts to smoke exposure remain under study.

6. The cooperation of air quality regulators, land managers and owners coupled with science and technology inputs are providing the tools to effectively manage fire and smoke from prescribed fires.

7. In the end, our society is faced with more fire and smoke from our nations wildlands. Either in the form of unplanned, destructive wildfires or from scheduled, well planned and ecologically beneficial prescribed fires.

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