

REM 244: Introduction to Wildland Fire Management

X. Air Quality and Smoke Management

- Impacts of Smoke
- Air Quality Regulations
- Modeling Smoke Production
- Smoke Management Techniques

FOR 454: Air Quality and Smoke Management

Adapted from online tutorial developed by J. Hyde

REM 244: Impacts of Smoke

Smoke is a collection of emission products resulting from the combustion process.

Definition: Particulate matter is any solid or liquid particle <100 microns in diameter that can be suspended by the atmosphere.

Several studies have shown that particulate matter has negative impacts on human health.

Air quality regulations mainly focus on PM 10 and PM 2.5.

70% of PM emissions are in the PM 2.5 size class

PM 2.5 has the greatest potential to affect human health as the small particles can be inhaled deep into the lungs.

Smoke during the 1988 Yellowstone Fires
Sources: www.frames.gov/smoke, NPS.gov

REM 244: Impacts of Smoke

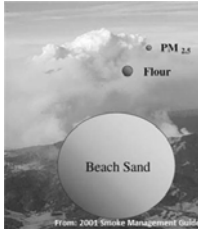
PM 2.5 is classified by the Environmental Protection Agency as a criteria pollutant. Criteria pollutants are required to have emission standards to protect the public.

Known short-term effects of PM2.5 exposure include:

Increased respiratory impacts (i.e. shortness of breath and coughing),
Changes in heart rate variability,
Irregular heart beat

Potential long-term effects of PM2.5 exposure include:

Reduced lung function, Chronic lung disease in children, heart and lung disease



Relative size of PM 2.5
Sources: www.frames.gov/smoke, Rx-410

REM 244: Impacts of Smoke

In addition to particulate matter smoke contains several other toxins that can be harmful to public health.

Acrolein: irritates eyes, causes nausea, and respiratory system distress even at low levels.

CO: reduces oxygen capacity in blood leading to disorientation and nausea. High levels can lead to heart attacks and death

Formaldehyde: irritant even at low levels. Long-term exposure linked to nasal cancer

Benzene: irritant even at low levels and has known links to various cancers.

Ozone: long-term exposure can lead to lung damage.



Smoke on a fireline.
Sources: www.frames.gov/smoke, Rx-410

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The Environmental Protection Agency defines Public Health as the "Incidence, prevalence and severity of diseases in communities or populations and the factors that account for them."



We must focus on communities that have a high probability of being impacted by smoke. Important factors include:

Location: Communities down wind from a burn, or in a low lying area where smoke may settle will be more affected.

Sensitive groups: Children, the elderly, and those with medical conditions are more sensitive.

REM 244: Impacts of Smoke

Fire personnel that work in close proximity to smoke are exposed to high concentrations of PM2.5 and toxins



Reinhardt and Ottmar (2004) found:

Rx fire personnel were exposed to higher levels of pollutants than wildfire suppression crews.

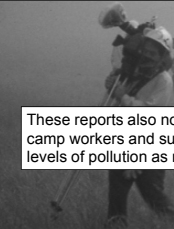
Crews on direct attack are exposed to the highest levels of pollutants.

Crews on initial attack were exposed to the lowest levels of pollutants

Source: Reinhardt, Timothy E., and Ottmar, Roger. 2004. Baseline Measurements of Smoke Exposure Among Wildland Firefighters. Journal of Occupational and Environmental Hygiene. 1:593-606.

Following these findings, Reinhardt and Ottmar (2004) and the National Wildfire Coordination Group (NWCG) recommended:

Amending health and safety standards to account for the long hours, heavy exertion, and high elevations often encountered by firefighters which often exacerbate exposure to pollutants



Improving firefighter awareness of health impacts, incorporating tactics to reduce fire fighter exposure, such as reducing mop up time, and better monitoring health and pollutant levels.

These reports also noted that due to close proximity to fires, base camp workers and support personnel can experience the same levels of pollution as many firefighters.

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Particulates in smoke can mix with moisture, to form thick fog banks called "super fog" in the southeast U.S. At night this dense fog can render car headlights useless, and is extremely hard to detect until encountered.

January 24th 2002: Wildfire Refuge staff conduct Rx fire on 852 acres. Burn was carried out with experienced crews.

Conditions: Burn day was clear and weather remained in prescription during the burn.

Smoke that day was carried north of I-75 and after the burn crews reported road free of smoke.



Source: www.frames.gov/smoke.

REM 244: Impacts of Smoke

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January 25th 5:05 AM: State troopers on I-75 respond to first of 8 accidents that involved 27 vehicles and led to 13 injuries and 3 fatalities.

A formal incident review found that the fire was well planned, operated correctly, and was carried out within all regulations and policies.



Examples of super-fog and its impacts.
Sources: USFS

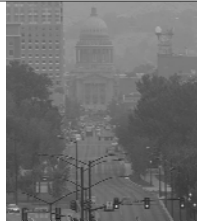
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The impacts from smoke have led the federal government, via the EPA, to protect public health via several air quality regulations. These regulations are important for protecting public health and welfare, and they have the potential to impact land managers' ability to use prescribed fire to meet land management objectives.

The main regulations that have been developed include:

- The Clean Air Act (CAA)
- State Implementation Plans (SIPs)
- National Ambient Air Quality Standards (NAAQS)
- NAAQS Compliance
- Class 1 Areas and the Regional Haze Rule (RHR)
- General Conformity **
- Exceptional Events Rule **

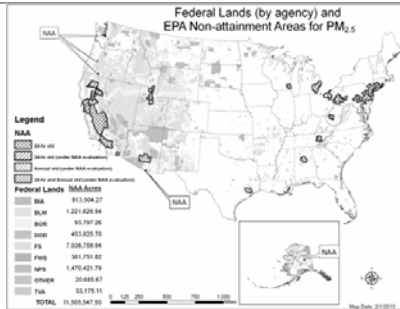
** Contained in online tutorial – see website



Smoke in Boise
Source: www.frames.gov/smoke

REM 244: Air Quality Regulations

PM 2.5 nonattainment areas for the 35µg/m³ 24 hour standard overlaid on federal lands.



Source: www.frames.gov/smoke

REM 244: Air Quality Regulations

The Clean Air Act (CAA) provided the legal basis for federal air quality standards and regulations. The implementation of this act is delegated to states and tribal governments.

Section 109

The EPA is required to establish National Ambient Air Quality Standards (NAAQS) limiting the ambient concentrations of certain pollutants.

Section 110

States must develop State Implementation Plans (SIPs) demonstrating how they intend to attain and maintain the National Ambient Air Quality Standards. These plans cover a variety of pollution sources, including wildland fire.



Sources: Florida department of health protection.
www.frames.gov/smoke.

REM 244: Air Quality Regulations

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Section 116

States have the right to develop and enforce more stringent air quality standards and regulations; states are not allowed to have less stringent standards.

Section 118

Federal Agencies must comply with air quality standards and regulations to the same degree as any non-governmental entity.



Sources: Alaska, Division of Air Quality.
www.frames.gov/smoke.

REM 244: Air Quality Regulations

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Sections 160-169

Designates certain wildernesses and national parks as mandatory Class 1 Areas. Class 1 Areas have the highest level of air quality protection with regards to additions of pollutants from new air pollution sources.

Section 169A

Class 1 Areas have a national visibility goal to remedy any existing impairment of visibility that results from human induced air pollution, and to ensure that level of visibility is maintained. This goal is the basis for the Regional Haze Rule.



Smoke over Camp Pendleton
Source: www.frames.gov/smoke.

REM 244: Air Quality Regulations

States write State Implementation Plans, or SIPs, to describe how they plan to comply with air quality regulations

States SIPs describe how they plan to comply with air quality regulations. Each must contain:

- EPA approved state regulations
- EPA approved orders to individual companies
- Planning documents on air quality or information on computer models detailing how plans will be met



Smoke from a wildfire in Sedona, Arizona. Source: www.frames.gov/smoke.

If states do not create a SIP, EPA will create instead a FIP (Federal Implementation Plan).

REM 244: Air Quality Regulations

The National Ambient Air Quality Standards, or NAAQS, are required by Section 109 of the Clean Air Act. These standards put a cap on the amount of certain pollutants, referred to as criteria pollutants, that are allowed in the atmosphere. The pollutants and their standards have been set by the EPA in response to the latest available research on air quality and human health.

The NAAQS are reviewed and updated every 5 years.

Consequences! Consequences! Consequences!

As NAAQS become more stringent, it becomes increasingly difficult to conduct prescribed fires.

The 2006 revision of the National Ambient Air Quality Standards lowered the 24-hour PM2.5 standard from 65 $\mu\text{g m}^{-3}$ to 35 $\mu\text{g m}^{-3}$, almost cutting them in half.

In 2010 the EPA proposed more stringent ozone standards.

The Healthy Forest Initiative and fuel management targets now require land managers to reduce fuels on a scale never before achieved.



REM 244: Air Quality Regulations

States have the responsibility to monitor air quality data and provide them to the EPA to demonstrate compliance with the NAAQS and SIPs. The EPA assesses compliance by analyzing 3 years of air quality data and assigns each county a score:

Attainment Areas: Where the measured concentrations of pollutants are less than or equal to the NAAQS.

Nonattainment Areas: Where the measured concentrations of pollutants are greater than, or exceed, the NAAQS.

Maintenance: An area previously in nonattainment which is now in attainment of the NAAQS. Additional requirements are applied to the area to ensure it remains in attainment.



PM 2.5 Non attainment areas in 2009. Source: www.frames.gov/smoke.

REM 244: Air Quality Regulations

The Regional Haze Rule (RHR) exists to protect visibility in Class 1 Areas. These areas describes national parks and wilderness areas designated by congress in 1977 as needing special goals to improve levels of visibility in these areas, to and prevent any further impairment of visibility due to human induced air pollution.

The RHR requires States to

1. participate in planning to reduce haze, regardless even if they don't have a Class 1 Area: because pollutants that contribute to haze, which are emitted in one State, can drift into other States;
2. develop long measures for all pollutant sources, including prescribed fire, and demonstrate reasonable progress in meeting visibility goals.





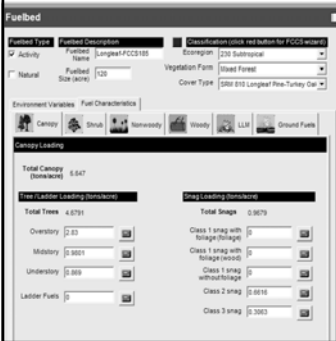
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- CONSUME Properties:
- Models the Fuel Consumption and Emissions of wildland or prescribed fires
 - Directly uses FCCS
 - Regional Equations
 - Can Add Own Fuel Loadings
 - Emissions by Phase

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REM 244: Modeling Smoke Production



- Fuels Data via FCCS
- Can Add Own Fuel Stratum Loadings:
 - Canopy
 - Shrubs
 - Grasses/Forbs
 - Woody Fuels
 - Litter/Lichen/Moss
 - Ground Fuels (duff)
 - Weather Zone

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Emissions by Combustion Phase
3/2/2007

Project Southern Example

Pollutant	Emissions by Combustion Phase (tons/acre)	
	Flaming	Smoldering
PM	0.07	0.05
PM ₁₀	0.04	0.03
PM _{2.5}	0.04	0.03
CO	0.34	0.26
CO ₂	13.01	2.76
CH ₄	0.01	0.01
NMHC	0.01	0.01

Project Southern Example
Unit Rx

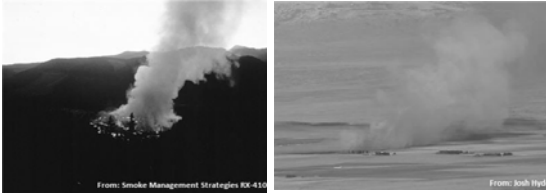
- CONSUME Outputs:
- Emissions of PM and Carbonaceous gases
 - Fuel Combusted
 - Radiative Heat Flux
 - Each by Combustion Phase

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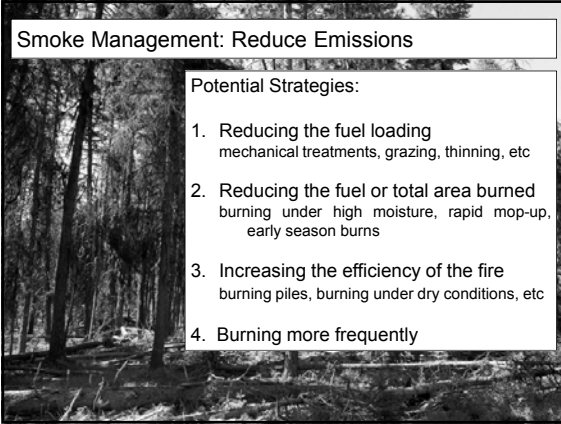
REM 244: Smoke Management Techniques

Two basic strategies exist to manage smoke emissions:

1. Reduce emissions at time of burning
2. Redistribute emissions away from sensitive areas



Smoke Management: Reduce Emissions



Potential Strategies:

1. Reducing the fuel loading
mechanical treatments, grazing, thinning, etc
2. Reducing the fuel or total area burned
burning under high moisture, rapid mop-up,
early season burns
3. Increasing the efficiency of the fire
burning piles, burning under dry conditions, etc
4. Burning more frequently

Smoke Management: Redistribute Emissions

We can also redistribute these emissions away from sensitive areas.



Potential Strategies:

1. Dispersing to the atmosphere: burning slowly or in unstable atmospheres allows smoke to disperse in a larger column.
2. Using cloud condensation nuclei: venting into rain clouds will cause smoke particles to bond with water molecules and fall as rain.
3. Removing fuels and burning elsewhere
